CIVIL ENGINEERING

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CALLES DAM PROJECT—AGUASCALIENTES, MEXICO
Laying Rubble Lining in the Main Canal

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AUGUST 1931

Cincinnati Union Terminal ordered their first MacARTHUR Cased Piles in January, 1930 . . . since then we have had 14 other contracts for this project, and the 6,595 pile contract for the Union Passenger Station

Typical pier of the 4600 MacArthur Cased Composite Piles driven for the Western Hills Viaduct, Cincinnati Union Terminal Company, Cincinnati, O. Col. Henry M. Waite, Chief Engineer.

Section of the 2542 MacArthur Composite Cased Piles driven for the City of Detroit, Mich., Dept. of Water Supply at Springwells Station site. Photo taken May 28, 1930.

THE Terminal development at Cincinnati is one of the *big* projects of 1930–31. After exhaustive tests the first contract for MacArthur Piles was placed in January of last year. Our handling of the contract was so satisfactory that we have secured *fifteen additional contracts.* The latest, received on April 22, was for 6,595 Piles to support the Union Passenger Station. Driving was started on April 30, and our speed schedule calls for completion on July 17.

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Composite Piles (*Cased Concrete and Wood*)

Fig. 1—Core and casing driven into the ground. *Fig. 2*—Core withdrawn and timber, with pan on shoulder, placed in casing. *Fig. 3*—Timber guided by casing, driven down to give necessary bearing. Butt of timber below ground water level. Core withdrawn and permanent shell inserted through casing and locked to timber and pan. *Fig. 4*—Casing withdrawn and concrete deposited in permanent corrugated shell.

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Experience	*21 years*	**Responsibility** .	*demonstrated*
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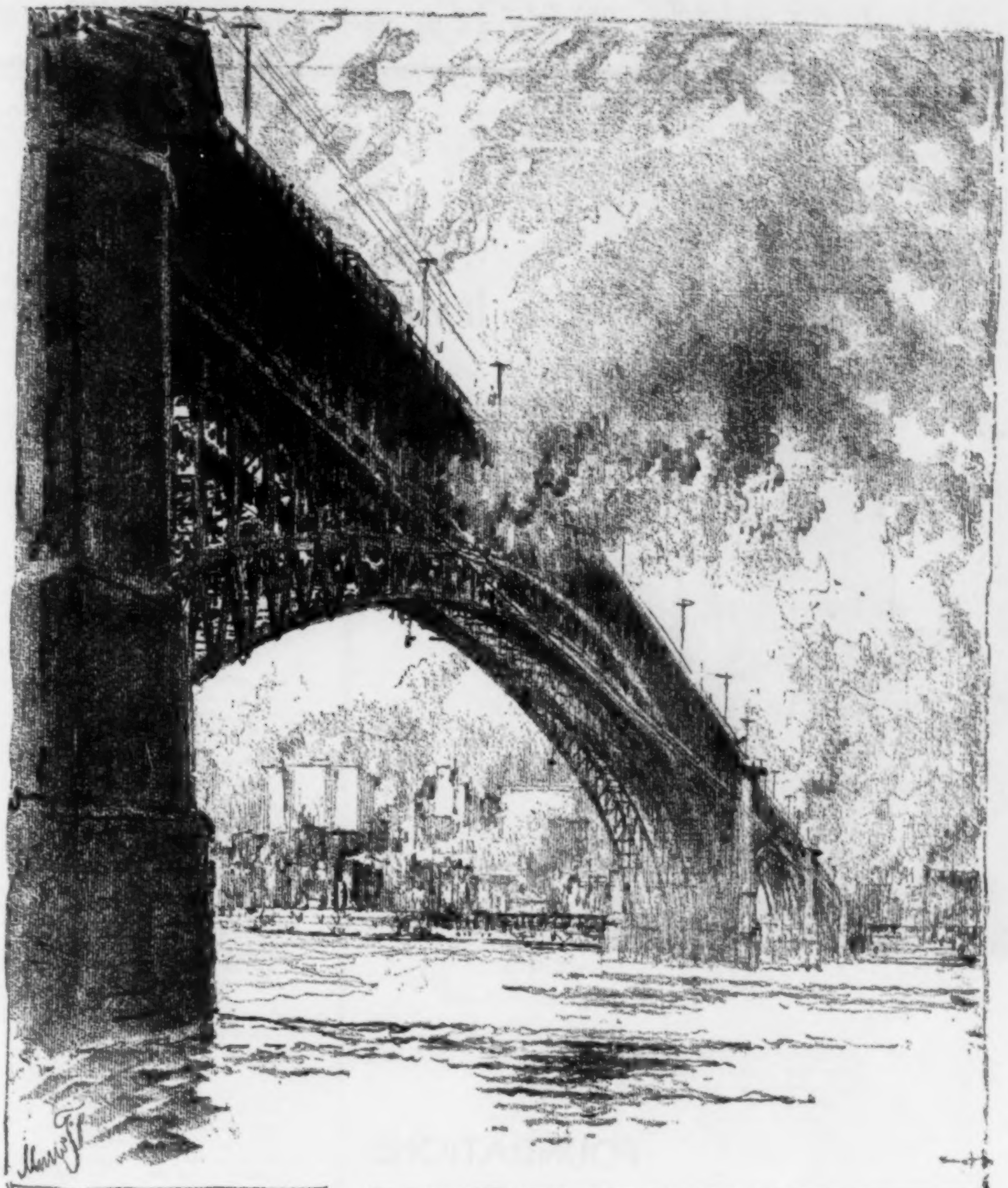

Joseph Pennell

THE EADS BRIDGE

ALTHOUGH built fifty years ago, this structure is today a remarkable example of bridge construction and stands as a monument to James B. Eads, under whom it was designed and built. The late Joseph Pennell, world famous artist, always interested in the great structures of the day, said of it, "The greatest bridge of its time—now there are three more of them, and this is thought old-fashioned, but it was built by a man who cared for line and he made one of the most beautiful bridges of modern times." Reproduced from an original by courtesy of L. A. Wuerth and by kind permission of Mrs. Joseph Pennell.

Among Our Writers

W. L. STEVENSON has, in his long engineering career, been responsible for the design, construction, and operation of numerous sewerage works for the City of Philadelphia. During the War he was Sanitary Engineer of the Emergency Fleet Corporation of the U.S. Shipping Board. In his capacity of Chief Engineer for the Pennsylvania Department of Health, he has been in charge of the sanitary survey of many streams and has negotiated various interstate stream conservation agreements.

CHARLES E. RYDER'S engineering services for the State of Pennsylvania began in 1907. As Secretary and Chief Engineer of the Water and Power Resources Board, he has been in immediate charge of stream gaging, has personally examined and reported upon more than half of the water-supply systems in the state and, since 1913, has passed upon the design and construction of all dams built in the state.

A. M. RAWN, prior to his work with the Los Angeles County Sanitation Districts, was for almost 20 years with the U.S. Bureau of Reclamation. Some of the more important engineering feats with which his name was connected during this period were the Yakima, Boise River, King Hill, and Columbia Basin projects.

ELWOOD MEAD'S engineering experience covers a span of half a century. He has served as consulting engineer on many irrigation and water works projects and, since 1924, has been U.S. Commissioner of Reclamation. As such he is in charge of the Hoover Dam Project, one of the greatest engineering efforts ever undertaken by the United States.

H. M. WESTERGAARD, a native of Denmark, has engineering degrees from universities both in this country and Europe. Since 1916, he has been on the faculty of the University of Illinois. During a leave of absence, 1929–1930, he was engaged by the U.S. Bureau of Reclamation in technical studies for the Hoover Dam project.

R. L. MORRISON has combined a career of teaching highway engineering in various universities with active engineering experience in such organizations as the Illinois State Highway Department, the Michigan State Highway Laboratory, and the United Gas Improvement Company.

AUGUSTIN M. VALDES, a graduate of the University of Dayton in 1925 and an engineering graduate of the University of Mexico in 1928, was engaged on the location of a portion of the highway between Laredo, Tex., and Mexico City. For four years he was connected with various irrigation projects of the Comision Nacional de Irrigacion. Under the direction of Julian Hinds, M. Am. Soc. C.E., he had charge of analyses, designs, and estimates of dams and structures on the Calles Project.

CHARLES H. LEE has made a specialty of the application of geology, groundwater hydrology, and soil mechanics to engineering problems, and is the author of various reports and technical papers on these subjects. In 1929 he established the Pacific Hydrologic Laboratory to further practical application of the principles of hydrology and soil mechanics in engineering practice. He is also in consulting practice in San Francisco.

J. P. KEMPER has, for 30 years, been a student of Mississippi River flood problems. He is noted as an opponent of the "levees only" method of control and the author of a work on *Floods in the Valley of the Mississippi*.

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Volume 1 August 1931 Number 11

New Water Laws in the Making

Principles Established by the U.S. Supreme Court in the Connecticut and Delaware River Cases

By W. L. Stevenson, M. Am. Soc. C.E.
Chief Engineer, Pennsylvania Department of Health, Harrisburg
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Chief Engineer, Water and Power Resources Board of Pennsylvania, Harrisburg

A NUMBER of new and fundamental points surrounding the use of water taken from interstate streams have been made clear by recent decisions of the U.S. Supreme Court. In their search for suitable additional domestic water, the engineers of both Boston and New York proposed to take water from upper tributaries, lying wholly within their respective states, of rivers that flow along or through adjoining states. Plaintiff states prayed to enjoin the proposed diversion but the Court based both decisions on equitable apportionment to the extent of no substantial damage. In the use of interstate water neither the doctrine of riparian right nor prior appropriation applies, and the water need not be utilized in the watershed of the stream from which it is taken. From a maze of testimony, briefs, arguments, and the opinions of the Court, the authors have here extracted the salient points, which mark an advanced interpretation, bidding fair to revolutionize previous ideas.

The U.S. Supreme Court has recently laid down, in the interstate stream cases of Connecticut vs. Massachusetts and of New Jersey vs. New York, the guiding principles regarding the utilization of such waters. Since the records of these cases are voluminous and not readily accessible to the profession, this article will very briefly review the most important legal and engineering features.

In the case of New York vs. New Jersey, 256 U.S. 296, the Supreme Court set forth its rule as to suits between states as follows: "Before this court can be moved to exercise its extraordinary power under the Constitution to control the conduct of one state at the suit of another, the threatened invasion of rights must be of serious magnitude, and it must be established by clear and convincing evidence."

The Connecticut River Case

Urgent need to augment metropolitan Boston's water supply led to the preparation of a plan for diverting, by gravity, water from the Ware and Swift rivers, which are relatively clean non-navigable Massachusetts tributaries of the interstate Connecticut River. The taking was authorized by the Massachusetts Legislature and permitted by the Secretary of War, who imposed certain limitations and required certain releases. Connecticut filed a bill of complaint to enjoin the diversion, alleging, among other things, that the common law doctrine of riparian rights forbade any such diversion, particularly out of the watershed, and that serious damage would result to navigation, power, agriculture, the sanitary condition of the river, and fisheries. The relation of the watersheds to the City of Boston is shown in Fig. 1.

The Court appointed Charles W. Bunn of Minnesota as Special Master. On February 24, 1931, Mr. Justice Butler delivered the opinion of the Court, dismissing the Connecticut bill of complaint without prejudice.

The Delaware River Case

The Delaware River is an interstate stream rising in New York and constituting the boundary, first between New York and Pennsylvania, then between New Jersey and Pennsylvania, and finally between New Jersey and Delaware. The legislatures of New Jersey, New York, and Pennsylvania in 1923 authorized the appointment of commissioners who negotiated a compact allocating the water resources of the Delaware between the three states. The compact was ratified by the Legislature of New York only. A second compact, negotiated in 1927, provided for the diversion of water from the Delaware River or its tributaries of 600 m.g.d. by New York, 600 m.g.d. by New Jersey, and 900 by Pennsylvania, with provisions for released flows. This second compact was not ratified by New Jersey or Pennsylvania.

New York, acting upon competent legal advice, then proceeded with its plan for diverting, at a rate of 600 m.g.d., the impounded waters of the Neversink River, Willowemoc River, Beaver Kill, East Branch of the Delaware River, and Little Delaware River, all relatively clean non-navigable tributaries of the Delaware River in New York State, and for releasing water in accordance with the rule of the 1927 compact. The plan was approved by the Water and Power Control Commission of New York State. This situation is shown in Fig. 2.

New Jersey filed a bill of complaint to enjoin the

State and City of New York from carrying out this plan, alleging, among other things, that it would cause substantial damage to navigation, water power, sanitary condition of the river, industrial use, oysters, shad fisheries, municipal water supplies, agricultural lands, and recreation; and that the common law rule of riparian rights forbade diversion, particularly out of the watershed.

It is significant that the Supreme Court permitted Pennsylvania to intervene, not in the customary rôle of a party plaintiff or defendant, but in the unusual character of an "intervenor" solely protecting its own interests and in no wise aligned with either of the two original litigants. This precedent as between litigant states should prove of value in future disputes over the utilization of interstate waters, since it will permit each interested state to intervene without taking sides, and to act solely in the protection of its own peculiar interests and needs.

The Delaware River case was referred to Charles N. Burch of Memphis, Tenn., as Special Master.

On May 4, 1931, Mr. Justice Holmes delivered the opinion of the Court allowing the New York diversion, in reduced amount, subject to certain conditions and the retention of jurisdiction. The Court said: "In a most competent and excellent report the Master adopted the principle of equitable division which clearly results from the decisions of the last quarter of a century."

One of the main contentions raised in both cases was as to the law to be applied. Should the ancient and local state rule of common-law riparian rights be followed, or was there a newer and higher law—the interstate common-law rule of equitable apportionment?

In answering this query in the affirmative, the Supreme Court, in the Connecticut River case, said: "For the decision of suits between states, federal, state, and international law are considered and applied by this Court as the exigencies of the particular case may require. The determination of the relative rights of contending States in respect of the use of streams flowing through them does not depend upon the same considerations and is not governed by the same rules of law that are applied in such States for the solution of similar questions of private right. . . . As was shown in Kansas v. Colorado, 206 U.S. 46,100, such disputes are to be settled on the basis of equality of right. But this is not to say that there must be an equal division of the waters of an interstate stream among the states through which it flows. It means that the principles of right and equity shall be applied having regard to the 'equal level or plane on which all the states stand, in point of power and right, under our constitutional system' and that, upon a consideration of the pertinent laws of the contending States and all other relevant facts, this Court will determine what is an equitable apportionment of the use of such waters."

In the Delaware River case the Supreme Court said: "A river is more than an amenity, it is a treasure. It offers a necessity of life that must be rationed among those who have power over it. New York has the physical power to cut off all the water within its jurisdiction. But clearly the exercise of such a power to the destruction of the interest of lower states could not be tolerated. And on the other hand, equally little could New Jersey be permitted to require New York to give up its power altogether in order that the river might come down to it undiminished. Both states have real and substantial interests in the River that must be reconciled as best they may be. The different traditions and practices in different parts of the country may lead to varying results but the effort always is to secure an equitable apportionment without quibbling over formulas."

GUIDING PRINCIPLES FOR USE OF INTERSTATE WATERS

1. The doctrine of equitable apportionment controls the division and use of interstate waters.

2. Priority of appropriation creates no superiority of right in interstate waters.

3. The highest use of interstate waters is for drinking and other domestic purposes.

4. Injunctive relief will be granted only upon proof of present and substantial damage.

5. Diversion will be allowed from one watershed to another.

6. States may select sources of water supply provided no substantial damage is done to sister riparian states.

7. Release of compensation water depends upon downstream river conditions and needs.

8. Judicial allowance of diversion affecting navigation or navigable capacity is conditioned upon Federal approval.

In the absence of a compact between the three states, Pennsylvania as intervenor contended, first, that an award by the Supreme Court to New York should not constitute a prior appropriation because this would make the doctrine of apportionment inoperative and institute a wasteful tri-state competition for the waters of the Delaware River; and second, that any such diversion should be taken reasonably into account in any subsequent or final allocation of the waters of the Delaware River and its tributaries among the three states.

The Court in its decree stated: "The diversion herein allowed shall not constitute a prior appropriation and shall not give the State of New York and the City of New York any superiority of right over the State of New Jersey and the Commonwealth of Pennsylvania in the enjoyment and use of the Delaware River and its tributaries." Therefore, although the water needs of a state may lie in the future, yet they will be recognized and protected. Each state may claim its fair and equitable share of water from interstate streams; and in the allocation of such water, the first taker may not claim more than its share and thus deprive another state of its quota. This ruling precludes any race for a preferred position as to limited interstate water.

Many uses of water were discussed in these cases, so it is important to note that the Court in its opinion on the Connecticut River case said: "Drinking and other domestic purposes are the highest use of water. An ample supply of wholesome water is essential."

In the same case, the Master heard testimony as to two ways of augmenting Boston's water supply—first, impounding relatively pure water from tributaries of an interstate stream; and second, purifying polluted water of intrastate streams.

The Master in his report referred to the divergent views of water experts and said: "The difference between them seems partly to be a difference between two schools of thought. One looks most favorably on the sinner repentant, the other will have none of him except on compulsion. The one school has the fullest confidence in the processes involved in modern treatment of polluted water and lays less stress on pure source of supply. It

suffices them to feel that water will be delivered to the consumer pure. The other school is skeptical about the infallibility of water purification processes and seeks waters that are pure at the source. They advise all cities and municipalities to obtain pure waters whenever practical, instead of treating polluted waters."

In the Delaware River case, the Master said: "The modern tendency is to obtain for municipal supply the purest water possible and to make this water better and not to obtain less desirable water and render it acceptable by treatment and purification, though insuperable economic considerations frequently compel the latter course."

SUBSTANTIAL DAMAGE NECESSARY FOR INJUNCTION

In the Connecticut River case, the Master and the Court found that carrying out the Massachusetts plan will not interfere with navigation, or do damage to the hay lands, to the shad run, or increase Connecticut River pollution. In the Delaware River case the Master found that the carrying out of the New York plan will have "slight" effect and no materially adverse effect on the navigation and navigable capacity of the river; and upon sanitation, municipal water supplies, industrial use of water, agriculture, and shad fisheries the effect would be "slight and immaterial." But he also found that it would cause "somewhat more than slight damage" to recreation and the oyster industry, and that "totaling all the effects of the New York diversion indicates a substantial damage to New Jersey and its citizens and a greater damage than New Jersey should be required to bear and more than New Jersey should be required to yield to other states in the enjoyment of a common stream. . . .Any substantial damage to New Jersey and its citizens can be removed by reducing the volume of the New York diversion and by modifying the plan of releasing water into the river from impounding reservoirs during periods of low flow in the river (thereby increasing the flow in the river during low stages), and by treatment of sewage and industrial waste at Port Jervis."

The Court in its opinion affirmed the Master and in its decree reduced the New York diversion from 600 m.g.d. to 440, and required the use of the Pennsylvania plan of release.

It is of interest to the engineer to note the legal viewpoint that the summation of several different kinds of "slight or somewhat more than slight" damage equals a "substantial" damage which can be removed by reducing the causes, that is, by reducing the amount of diversion and pollution load and by increasing the refreshing influences, by a rule of releasing stored water.

Connecticut claimed that the Massachusetts diversion would adversely affect the development of power, and on this the Master said: "Only one possible power development is shown. This is at King's Island, in Connecticut near the state line where 4,000 horsepower is now developed at a 24-foot head. The company which owns this power has been authorized by the Federal Power Commission to build a higher dam to develop approximately 50,000 horsepower. This work, so far as the testimony shows, has not been resolved on by the company, and so far as shown the required capital has not been subscribed or arranged for."

And the Court included in its opinion: "At most there is a mere possibility that at some undisclosed time the owner, were it not for the diversion, might construct additional works capable of using all of the flow of the river including the waters proposed to be taken by Massachusetts. Injunction will not issue in the absence of actual or presently threatened interference. The facts disclose no basis for relief in respect of that property." And the Court also said: "Injunction issues to prevent existing or presently threatened injuries. One will not be granted against something merely feared as liable to occur at some indefinite time in the future."

In the Delaware River case, one of the objections of New Jersey to the New York diversion was that it would injuriously affect water-power rights and the ability to develop water power on the Delaware River. Much testimony was submitted by New Jersey intending to show the feasibility of hydro-electric power development. The Master found that there was no definite project for the development of power on the Delaware River and said: "The whole matter seems to reduce itself substantially to this, to wit, that there may be formulated at some time in the indefinite future a plan for constructing dams in the Delaware River and its tributaries to be operated as one whole system and, in the event this is done, and in the further event that Congress, the States of New York, New Jersey and Pennsylvania grant their consent, then in such event the carrying out of the New York plan would interfere with the execution of such project. It seems to me that this does not form a basis for injunctive relief."

FUTURE WATER SUPPLY DEVELOPMENTS

Pennsylvania contended that Philadelphia and other Pennsylvania municipalities must depend upon the tributaries of the upper Delaware River as a source of future water supply, and introduced proof to show that Philadelphia and Eastern Pennsylvania would by 1980 have need of 750 m.g.d. from the Delaware River and its tributaries for purposes of municipal water supply.

The Master reported: "The proof of Pennsylvania, however, failed to show that there was any officially authorized plan or any definite project for the taking by Philadelphia and Eastern Pennsylvania of 750 million gallons daily"; and also, "The judicial power of the Court under the Constitution extends only to actual cases and controversies and the court is without power to render a declaratory judgment to the effect that, in the event the City of Philadelphia and Eastern Pennsylvania should desire to take waters from the Pennsylvania tributaries of the Delaware they would be entitled to 750 million gallons daily."

In its decree the Court said: "The prayer of the intervenor, Commonwealth of Pennsylvania, for the present allocation to it of the equivalent of 750 million gallons of water daily from the Delaware River or its Pennsylvania tributaries is denied without prejudice."

The Master in the Connecticut River case found the Connecticut River to be polluted both from sewage and factory wastes. But in both direct and cross-examination it was stated that nobody would be able to tell the difference if 5 per cent of the water or of the oxygen were taken out or added to the river at the state line. The diversion represents an average yearly subtraction from the flow of the Connecticut at the State line of about 2

per cent. The Master reported that the proposed diversion would not perceptibly increase Connecticut River pollution and this was affirmed by the Court.

Sanitary surveys of the Delaware River were independently made by New Jersey and Pennsylvania during the low flows and warm weather of the summer of 1929 and the results submitted in evidence. There also was much testimony as to the effect upon the sanitary condition of the Delaware of diversions and releases, and the Master said that the Delaware River is a large stream and a relatively clean stream in the non-tidal section, with the exception of a polluted condition from sewage and industrial wastes immediately below Port Jervis, but that this impairment can be eliminated by requiring sewage treatment at Port Jervis and by changing the amount of water taken by New York City and the plan of release. In accordance with the recommendation of the Master, the Court placed in its decree a requirement for the treatment of Port Jervis sewage, "to effect a reduction of 85 per cent in the organic impurities" and a reduction of 90 per cent of B.coli. It also required treatment of industrial wastes to render them practically "free from suspended matter and non-putrescent."

In both cases the plaintiff states objected to diversion of water from one watershed to another. The masters and the Court held that the diversion of a state's equitable share to another watershed was not in itself a ground for injunctive relief.

In the Delaware River case the Court, having stated that the principle of equitable division clearly results from the decisions of the last quarter of a century, continued: "Where that principle is established there is not much left to discuss. The removal of water to a different watershed obviously must be allowed at times unless States are to be deprived of the most beneficial use on formal grounds. In fact, it has been allowed repeatedly and has been practiced by the States concerned."

In both cases the plaintiff states objected to the use of interstate waters because they alleged and submitted voluminous evidence to show that intrastate sources must be exhausted before resorting to interstate supplies. The Court in both cases upheld the right of a state to select its own water supply, subject only to the limitation that the choice of interstate waters must not cause serious damage to other states.

Connecticut submitted in evidence two projects for increasing the water supply of Boston from intrastate sources. The first was from 15 separate watersheds,

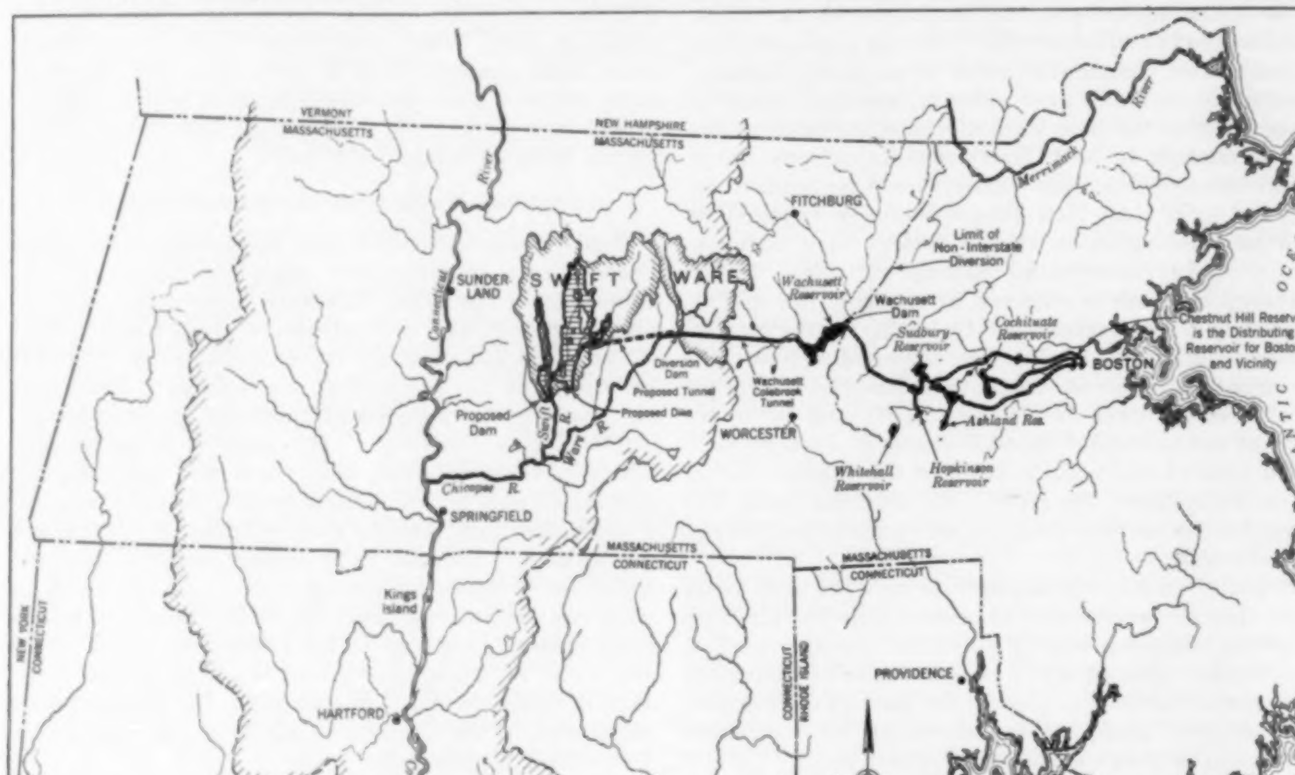

FIG. 1. PROPOSED INTERSTATE WATER DIVERSION FOR BOSTON, MASS.
Connecticut River Watershed

most of the water of inferior quality, some of which would have to be filtered and some pumped. The second was to pump water from the Merrimack River, of which a large part of the catchment area is in New Hampshire, is populated, and has a large factory development upon it, so that the water is polluted and there is no certainty of its improvement.

It was agreed by all the witnesses that such water would need full and complete modern treatment, and thereby could be made hygienic. But the Master said the first and one of the most important objections is that treatment introduces a human element subject to all the weaknesses and failures of human nature.

The Master also recognized the weight of public opinion and stated: "The people of Massachusetts are not accustomed to fitting by modern treatment badly polluted waters. It is natural that such people should have a peculiar hostility to polluted water. Our governments in the long run are controlled by public opinion. And while an expert on water, acting in a strictly professional capacity, may say that he will disregard public opinion, municipal and other governments cannot take that stand. The courts, it seems to me, cannot close their eyes to the necessities imposed by public opinion on governments." He also said: "It seems to me the court upon the evidence given cannot undertake to administer the internal affairs, including water supplies present and future, of northeastern Massachusetts. . . . I find the taking from the Merrimack ought not to be imposed upon the Boston District." The Court approved the Master's conclusion.

In the Delaware River case, New Jersey submitted a number of plans whereby New York could obtain ample increase of her water supply from intrastate sources, therefore alleging "non-necessity" to divert interstate waters. The Master discussed this and said: "The whole question is, have the State of New York and the City of New York the right to make use of the tributaries of the Delaware River as a source of water supply for the City of New York? My conclusion is that they are not precluded from so doing merely for the reason that there are other sources of supply in the State of New York, the taking from which could not affect other states." The Court affirmed the Master.

Release of Compensation Water Required

In both the Connecticut and Delaware River diversions, water will be released from storage for the purpose of augmenting the flow in the Connecticut and Delaware rivers at certain times of the year or stages in the river, and in specified amounts. The Supreme Court, in the Delaware River case, definitely fixed the rule of release, whereas in the Connecticut River case there was no such determination by the Court. In the Massachusetts diversion, the Secretary of War "required a discharge from the Swift river reservoir during the critical period

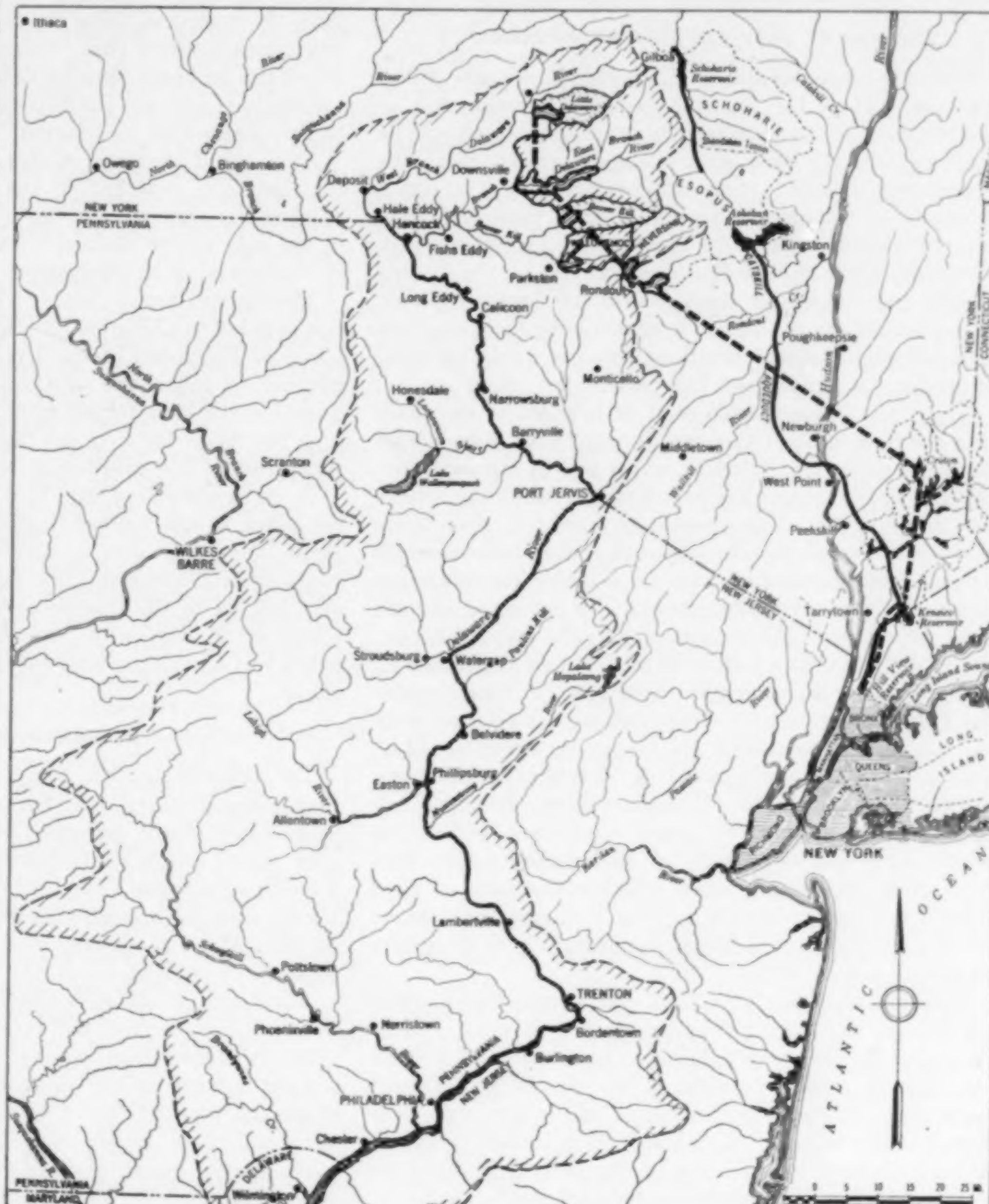

Fig. 2. Proposed Interstate Water Diversion for New York City
Delaware River Watershed

of low water, which would increase instead of diminish the flow of water in the Connecticut, and to that extent better navigation."

In the case of the Ware River, the Secretary of War permitted diversions in excess of a river discharge at the rate of 1.34 c.s.m. (sec-ft. per sq. mile of tributary drainage area), between October 15 and June 15, and prohibited the taking of any water for the remaining four-month period of the year. Releases were required from the Swift River Reservoir at the rate of 0.17 c.s.m. throughout the year, except that during the six-month period between June 1 and November 30, it will be necessary to release 0.59 c.s.m. when the flow in the Connecticut River at Sunderland is less than 0.58 c.s.m., and 0.38 c.s.m. when the flow is less than 0.61 c.s.m. and more than 0.58 c.s.m. "The Secretary of War. . . made orders modifying and reducing the diversion of Ware and Swift water which would have been possible under the Massachusetts legislation."

RELEASE OF DELAWARE WATER DETERMINED

The rule for releases in the Delaware River case differs materially from the War Department requirement in the Massachusetts diversion, as no release at all will be required from the New York storage reservoirs when the flow in the Delaware River at Port Jervis or Trenton is in excess of 0.5 c.s.m. The New York plan of release and the modified plan developed by the Commonwealth of Pennsylvania, which plan was adopted by the Special Master and included in the decree of the Supreme Court, were founded on the principle of releasing compensation water during times of low flow, when it would be most advantageous to the various needs for water.

Under the Pennsylvania plan of release, at any time that the flow in the Delaware River at Port Jervis or at Trenton falls below 0.5 c.s.m., water will be released from the impounding reservoirs in sufficient quantity to restore the flow to 0.5 c.s.m., provided, however, that there is not required to be released at any time more than 30 per cent of the average rate of yield of the diversion area. As the evidence showed the average run-off from the New York diversion area to be 2.2 c.s.m., the Court determined that 30 per cent of this amount, or 0.66 c.s.m., was the maximum rate of release under the Pennsylvania plan. This plan was developed with the intention of devising a rule for release which would be flexible enough to apply to any development for diversion of the tributaries of the Delaware River in any or all three states, up to 1,750 m.g.d. without injury to the river. The maximum rate of release under this plan is variable, depending upon whether the rate of yield from the diversion area is high or low, and this feature of the plan makes possible its application over the entire Delaware basin.

In comparing the New York and Pennsylvania plans of release, the Special Master stated, in part: "The theory of the Pennsylvania plan of release (and I think this theory sound) is that water should be released from the impounding reservoirs whenever the river drops to a low stage at either Port Jervis or Trenton. In this manner the regimen of the river between Port Jervis and Trenton can be better preserved"; and, "I also find that when the natural discharge of the river at Port Jervis is low, that flow will generally but not always be increased under the operation of the New York plan of releases and will always be increased under the operation of the Pennsylvania plan of releases. I am using here the term low flow as a flow below .45 c.s.m. (1,381 c.f.s.)."

It has been noted how the Master and the Court in the Connecticut River case recognized the limitation of diversion by Massachusetts of the Swift and Ware waters by the Secretary of War in the interest of navigation. In the Delaware River case, the Master called as his own witness George B. Pillsbury, M. Am. Soc. C.E., Assistant Chief of Engineers of the United States Army, who became well acquainted with the proposed plan of the City of New York while acting as District Engineer at Philadelphia. It was testified by General Pillsbury that careful and detailed computations were made by the Army engineers to determine the effect of the proposed diversion and releases on navigation and on the navigable capacity of the Delaware River. He gave the results of these studies at various stages of the river, and testified that "these small differences are far below the accuracy obtainable in dredging and surveying the channel and are far beyond the practical utilization of the channel for navigation."

As a result of these studies, General Pillsbury said: "I, therefore, reported to the Department that in my opinion the Department was not justified in intervening in the case at the present time on account of the effect of the diversion on navigation."

The Master found that: "The City of New York has not applied to Congress or the Secretary of War or the Chief of Engineers of the United States Army for permission to make the proposed diversion, but has acquainted the War Department with its plan of diversion and the War Department has been furnished with a transcript of the proceedings in this cause."

In its decree, the Court said: "This decree is without prejudice to the United States and particularly is subject to the paramount authority of Congress with respect to navigation and navigable waters of the United States and subject to the powers of the Secretary of War and Chief of Engineers of the United States Army in respect to navigation and navigable waters of the United States."

FINDINGS SUMMARIZED

To recapitulate, the Supreme Court of the United States has declared that the division and use of interstate waters is not governed by the local law of the litigant states but is controlled by interstate common law, a guiding principle of which is equitable apportionment. Under such an apportionment, each state is entitled to its fair share; and priority of appropriation confers no superiority of right.

Furthermore. the diversion of interstate waters, even to another watershed, will be permitted in the absence of proof of substantial damage resulting therefrom, but subject always to the approval of Federal authorities respecting navigation. The selection of interstate waters as a source of supply is primarily a matter of state sovereignty, providing sister states do not thereby suffer serious injury. As an incident to such a selection, the Court may prescribe as a condition that compensation water be released from the impounding reservoirs.

periodically by inserting an air jet along

Degree of stratification was deter-

Novel Sludge Digestion Tanks Completed

Separate Digestion of Primary Clarifier Sludge from Forty Million Gallons of Sewage Daily

By A. M. Rawn

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In designing the sludge digestion tanks which have just been completed at the Joint Disposal Plant of the Los Angeles County Sanitation Districts, advantage was taken of the greater specific gravity of the more completely digested sludge. In a series of four tanks to each battery, the inert solids, which settle to the bottom of each tank, are progressively moved forward by gravity to the top of the next tank, leaving the lighter, more volatile materials behind for a longer digestion period. More than enough gas is to be collected to heat the sludge to the temperature most favorable for rapid digestion. Interior circulation of sludge will be handled by simply designed gas lifts utilizing compressed captured gas and operating on the air-lift principle. This paper, originally presented before the Sanitary Group of the Los Angeles Section of the Society, aroused much interest in this nearly automatic sludge digestion plant.

From a review of current practice in separate sludge digestion it is evident that the popular method for achieving this objective is to run the raw sludge into tanks equipped with stirring or mixing devices, permit it to undergo a period of bacterial decomposition ranging in length from 35 days upward, and then draw from the tank bottom a concentrate of ripened sludge. Most such tanks are operated on a continuous basis, that is, after they are once filled, the raw sludge additions are compensated for by the drawing off of digested sludge and supernatant liquid—regulated somewhat to meet sludge drying facilities.

Some digestion plants operate on a sludge circulation principle, and mixing is accomplished by drawing ripe sludge from the bottom of a tank and discharging it again into the same tank at the top. Such tanks have as a rule no other mechanical stirring devices and operate on a continuous basis in other respects. There is also a draw-and-fill process known as stage digestion, in which mixing is accomplished by emptying the entire contents of one tank into another, at a certain stage in its digestion, by which process it is thoroughly mixed or stirred. Combinations of the types of tanks have been used from time to time, and it is usually found that any means which will stir up the sludge constantly or periodically, releasing entrained or entrapped gases and seeding the top material with that from the tank bottom, appears to increase the efficiency of the process and shorten the time required for digestion.

A characteristic of sewage sludge is that, when digested, it has a higher specific gravity, on the average, than when undigested. It is also well known that a high percentage of sewage solids is inorganic and that upon these the digestion process has no important effect. These inorganic solids are also, as a rule, heavier than the run of organic solids. Sludge digestion is essentially the reduction of organic material by liquefaction, gasification, and change, to a more stable composition. Thus the digested sludge is a combination of the original inorganic, the metamorphosed organic, and such other organic solids as the reduction process will not influence. The time of detention, other factors being equal, has a major influence on the reduction of the organic solids, and if this influence can be brought to bear upon the selected organic materials, with the inorganic materials separated out and passed ahead with the ripened sludge, it may be seen that a tank or group of tanks of given capacity may be thus used to digest a larger gross quantity of solids than when the entire bulk is retained in the tanks until completely digested.

On this principle of the segregation of solids, the new sludge digestion tanks recently completed at the Joint Disposal Plant of the Los Angeles County Sanitation Districts have been designed. Coupled with the main feature are interesting facilities for gas collection, temperature control, pH adjustment, and sludge recirculation, the latter by two independent processes.

Tests Justify Design

Before designing these tanks, a plant scale experiment incorporating their main features was conducted. For this experiment, two idle clarifier tanks and five idle aeration tanks were used, as shown in Fig. 1. The tanks were uncovered and no temperature adjustment was attempted. Raw sludge was pumped into one of the 35-ft. square clarifiers (I), where pH adjustment was

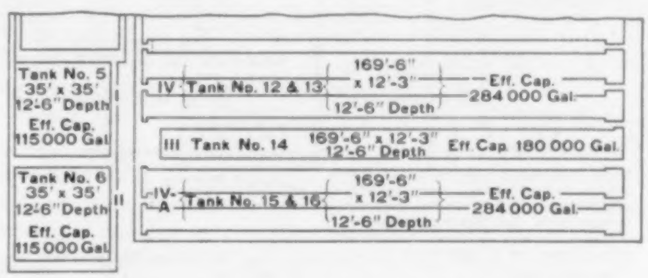

Fig. 1. Experimental Series on Sludge Digestion

made—originally by liming and later by the addition of predetermined quantities of ripened sludge.

From the bottom of the first clarifier (I), sludge was withdrawn and placed in the next clarifier (II). From the bottom of the second clarifier tank, it progressed in order to one of the long narrow aeration tanks (III), from the bottom of which it was pumped to one of two pairs of similar aeration tanks (IV and IVA) parallel to and alongside of the aeration tank. This constituted four steps in progression, each succeeding stage tank being filled with sludge from the bottom of the next preceding. Mixing in each tank was accomplished

segregation. Tank No. 2

periodically by inserting an air jet along the tank bottom and rolling the sludge upward with air bubbles.

As contrasted with the draw-and-fill stage process previously mentioned, in which the entire content of one tank is transferred to the next succeeding, all of these experimental tanks were kept filled, the sludge daily transferred ahead being equal in amount to the additions to Tank No. 1. Thus only such solids as might readily sink to the bottom of each tank were advanced to the next.

Although no temperature adjustment was possible, the results were very satisfactory. Sludge containing 65 per cent of organic solids was reduced to that containing 43 per cent of solids in 20 days in summer temperatures, resulting in a fast-drying, homogeneous, inodorous sludge. Such reduction compares favorably with the optimum readily obtainable at this plant, which is a sludge containing 33 per cent of organic material at the expiration of 120 days of digestion.

Sludge Tank Construction
June 1, 1931
Sludge Drying Beds and Clarifiers in Background

On a smaller scale, digestion was tried with temperature adjustment. This experiment was conducted in a wood-stave tank 7 ft. in diameter and 22 ft. deep, with a sludge depth of 20 ft. Temperature was maintained at 85 deg. fahr., and the pH adjusted by the addition of seeded sludge. Gas was collected and measured and circulation maintained with an automatic gas-lift device. The experiment, while not along the lines of stage digestion, served many purposes.

Degree of stratification was determined, that is, the segregation of solids occurring at different levels was measured and the solids at several levels were analyzed for organic and inorganic content, and for fats. The quantity of gas per unit of volatile content was determined and the acceleration of digestion due to heating, as well as the heating requirements, were found. Thus this experiment, coupled with the large-scale stage experiment, produced facts concerning the process upon which the details of a plant design could be based.

So that a clear conception of what is being accomplished with the new tanks may be gained, the progress of the raw solids will be traced from the sewage intake to the sludge drying beds, after which some of the design elements will be considered.

Solids from the raw sewage at the Joint Disposal Plant are at present collected in four primary sedimentation tanks, each 12 by 12 ft. in section and 50 ft. long. They are removed from the tank floors to end hoppers with continuous bottom sweeps. From the sedimentation tanks, the solids are pumped, at a moisture content of about 96 per cent, to a parallel fifth tank exactly like the other four, in which they concentrate overnight. From the fifth, or "thickener tank," they are drawn, at an average moisture content of 90 per cent, and introduced into Tank No. 1 of one of the batteries of sludge digesters, shown in Fig. 2.

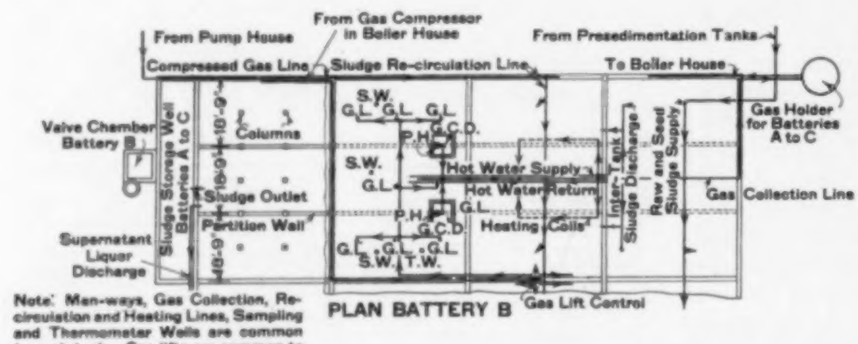

Fig. 2. Typical Plan and Sections of Sludge Digestion Tanks

With the incoming raw solids there is introduced approximately 20 per cent by volume of well digested seed sludge, the purpose of which is to promote the optimum pH and introduce the necessary bacteria for accelerated digestion. Raw sludge and seed are delivered into the two outside bays of the first tank of a battery. The outer bays are separated from the middle bay by curtain walls extending nearly to the tank bottom. Thus the separation of sludge into its component parts by specific gravity begins immediately, because it is necessary for sludge to sink to the bottom of the mass to get to the central bay.

From the end hopper, located in the central bay, sludge is delivered by gravity into the two outside bays of Tank No. 2 through two diagonal riser pipes. The flow from the central bay of Tank No. 1 to the outer bays of Tank No. 2 is dependent on the sludge level in Tank No. 1, and therefore corresponds roughly to the inflow of raw and seed sludge. The only sludge which can progress to the second tank must come from the bottom of Tank No. 1, and advantage is here again taken of

segregation. Tank No. 2 is a duplicate of Tank No. 1 except that a little less freeboard is provided for scum and foam. The process of progression to and through each succeeding tank of the four is alike in that only bottom sludge is constantly moving ahead. Throughout, advantage is taken of the disposition of the heavier, more inert solids to settle to the bottom in that they are selected constantly for progression, while the lighter constituents, containing the largest proportion of volatile solids, lag behind and undergo a longer detention period, with its resultant advantages. From the sludge storage well following Tank No. 4, sludge is pumped to the drying beds.

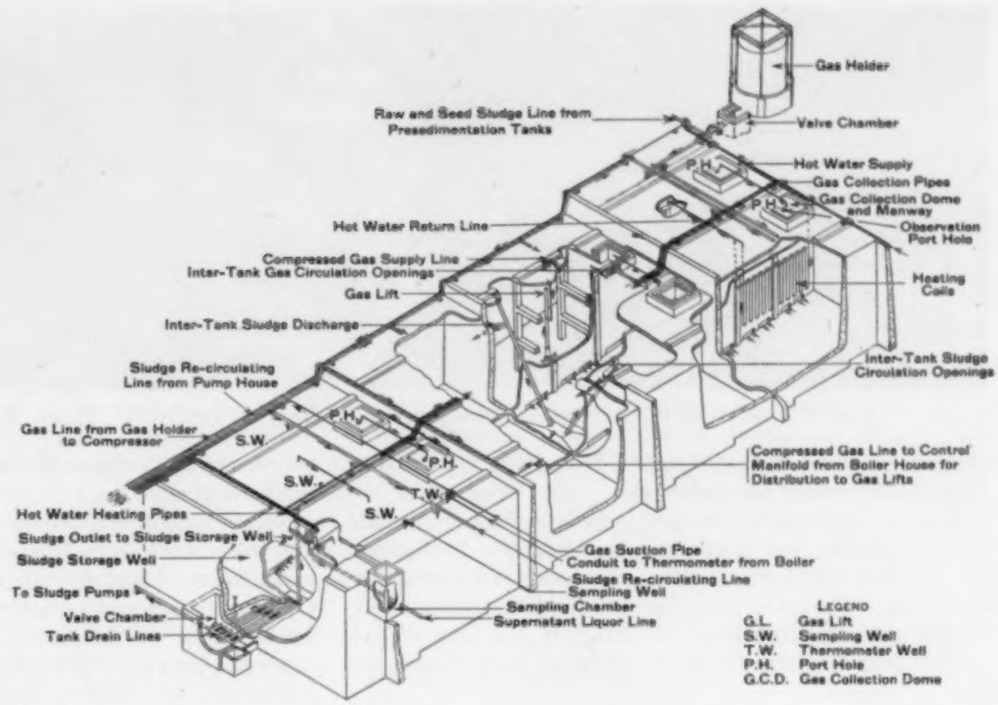

FIG. 3. SKELETON SKETCH OF ONE DIGESTION UNIT

Tanks 1, 2, and 3 are equipped with gas lifts for interior circulation. These are simple in construction and economical in operation; they are designed on the air-lift principle, but use captured gas in place of air. They have great proportionate submergence and high resulting efficiency. It is thought that periodic recirculation by this method will prove sufficient. However, each tank is also equipped so that sludge may be recirculated within the tank with pumps, a method somewhat more expensive but already proved successful. The last-mentioned operation is accomplished at small additional cost in this set-up and is thought advisable until the merit of gas-lift recirculation is proved beyond doubt.

There are no gas lifts in Tank No. 4. In this tank an effort is being made to draw off supernatant liquid, for which provision has been made. It is thought that supernatant liquid from Tank No. 4 will be inodorous and otherwise inoffensive as contrasted with that from a single tank operated on a continuous basis, where the supernatant liquid removed contains an undigested solids content of high bio-chemical oxygen demand, and is potentially putrefactive.

GAS-TIGHT COVERS PERMIT GAS COLLECTION

All of the tanks are covered with a concrete slab so designed as to permit of contraction and expansion without cracking. The top slab, 8 in. in thickness, is joined to the walls with copper flashing. This slab is attached to columns and curtain walls and rests on the continuous wall bracket. Gas will be exhausted from the tanks with an automatically operated gas pump, which will start and stop with slight changes of internal tank pressure, a feature considered advisable because of past inability to secure gas-tight concrete slabs. The top slab will be entirely covered with 12 in. of earth.

Entrance into each tank is provided through a manway closed with a water-sealed cover. Each cover is provided with a ship's port-hole light for observation. The manways also serve as gas collection domes. There are three sampling wells in each tank, one to a bay. Each consists of a 6-in. pipe extending through the top slab, submerged 3 ft. at the lower end. All are capped.

Tanks 1, 2, and 3 are each equipped with eight recirculation gas lifts, three in each of the outer two bays and two in the middle bay. In addition to vertical circulation, these lifts disturb the bottom sludge enough to keep it moving along. The bottom slope of the floors is designed from data given by John R. Downes in *Water Works and Sewerage,* July 1930, as substantiated by observation at the Joint Disposal Plant. The vertical offset of the four tanks in each battery is based on experience at the Joint Disposal Plant.

Each battery is roughly 150 by 50 ft. in plan, with a sludge depth averaging 15 ft. The tanks are about 37 by 50 ft. in plan, each divided into three connected bays approximately 37 by 17 ft. in plan. The capacity of each battery is therefore about 900,000 gal., which, on the basis of the amount of sludge captured at the plant, will treat the primary clarifier solids from 20 m.g.d. for an 18-day detention period. Results at the plant indicate that this should be about the average period of detention. Thus the two batteries are seen to have a sludge capacity capable of caring for the settled solids from a flow of 40 m.g.d. of sewage.

In the accompanying panoramic view, the double-plank footway in the foreground leads to the corner of Tank No. 1 of Battery B. On the top of this tank may be seen the two manways which lead into the three connected bays of Tank No. 1. Tank No. 1 of Battery A, the two manways of which are also visible, is in the left background. The first vertical offset to the right of Tank No. 1 Battery B, is to the top of Tank No. 2; the second, to Tank No. 3; and the third, to Tank No. 4. The

RAW SLUDGE INLET PIPING AND SLUDGE CIRCULATION PIPES ON THE No. 1 TANKS OF BATTERIES A AND B

pipe line leading over the right edge of the tops of the tanks is for sludge recirculation.

The raw sludge inlet line may be seen in the foreground, in front of the first manway into Tank No. 1, Battery B. In the left foreground is the concrete gas-holder structure. The metal tank has not yet been constructed. Another illustration shows a detail of the raw sludge inlet piping and the sludge circulation pipes on the two No. 1 tanks.

The contract price of the two batteries complete is \$107,000, to which must be added the cost of the pumps, about \$3,000 installed. At a total of \$110,000 for the complete unit, the cost per million gallons of flow is \$2,750, a price which it is thought compares favorably with that for separate digestion elsewhere.

Should the units as built be used to digest solids from complete treatment, such as by activated sludge, then the capacity of the digestion plant will be reduced by about one-half, and the unit cost for the construction will be doubled.

Gas production is expected to be about six times the gas requirement for sludge heating and, as need dictates, a use will be developed for the excess. Specifically, each battery should develop about 50,000 cu. ft. of gas per day, having a calorific heat value of about 700 B.t.u. per cu. ft. Of this, about 8,000 cu. ft. per day will be required for heating. Radiation losses per battery per day are computed at 4,000,000 B.t.u., and heating requirements at an additional 7,000,000 B.t.u. Many uses are suggested for the excess gas, among which the most promising are incineration of screenings and mechanical sludge drying.

Temperatures will be measured by electric indicating thermometers located in each tank and on hot and return water lines. Heating coils are placed in each bay, with the larger surface of radiation in the No. 1 tanks. Water for the coils will be heated in a 20-hp. boiler and will enter the lines at 135 deg. fahr., returning at 100 deg. F. Automatic gas control, both on and off, is provided.

Each tank is so designed that it may be by-passed and cut out of the process. The same hook-up of lines to pumps, with small additional piping, forms a sludge recirculating system. The same battery of pumps, two in number, will be used for seeding, recirculation, or discharging to sludge beds, as required.

The entire process was designed to secure simplicity of construction and operation. The tank design is plain and rectangular, with full advantage taken of community walls. Should the recirculation of sludge within the tanks be accomplished satisfactorily by the gas lifts, all other digestion operations will be automatic, except the decantation of the supernatant liquor which, with sludge thickening, may not be advisable. If the tanks perform as anticipated, the operation costs should be very low.

Designs for this plant were made under the direction of A. K. Warren, Assoc. M. Am. Soc. C.E., Chief Engineer of the Los Angeles County Sanitation Districts, and construction of the work described was done by contract. The work was completed and the plant placed in operation on July 1, 1931.

MEER ALUM DAM
Hyderabad, India

This dam was built about 1790. The exact date is uncertain.

Courtesy of the late Harry Hawgood, M. Am. Soc. C.E., of Los Angeles

Ample Security for Hoover Dam

Engineers of Bureau of Reclamation Refute Criticisms of Foundation and Design

In a structure of the immensity of Hoover Dam, questions of engineering analysis and procedure are bound to arise. Following the appearance of an authoritative statement by Dr. Elwood Mead, in the October 1930 issue of Civil Engineering, *discussion of this stupendous project ensued in these pages over a period of months. When M. H. Gerry's comments arrived the discussion had already been closed; but in view of the basic nature of his questions and the need for thrashing out the issues raised, his criticisms were printed as a paper entitled "Safety Limitations of the Hoover Dam," in the July number, page 921. Immediately wide notice was given this matter in the daily press throughout the country, illustrating the popular interest in anything pertaining to Hoover Dam. In the accompanying articles, Dr. Mead and Professor Westergaard take up the cudgels for the Bureau. Believing that Mr. Gerry's paper contains unsound arguments, incorrect statements, and illogical conclusions, they answer specifically and in detail. Their assertions should serve to allay any misgivings as to the security of the world's greatest dam. Further comments from other interested engineers are expected to appear in later issues of* Civil Engineering.

A Conservative Design

By Elwood Mead

Member American Society of Civil Engineers
Commissioner of Reclamation, Washington, D.C.

There never has been a dam more accurately, more carefully, and more conservatively designed than Hoover Dam. It contains ample factors of safety against failure by sliding, against failure by overturning, and against failure by crushing. Hoover Dam is safe as a gravity dam. It is safe as an arch dam. It is doubly safe as a combined arch-gravity dam. It is safe against overtopping, against earthquake shocks, and against any combination of loads. The probability of the occurrence of uplift pressure at the base of the dam and the possibility of the occurrence of such pressure in the interior of the great mass of concrete which forms the dam have been properly considered. There is no possibility whatsoever that the St. Francis Dam disaster will be repeated on an exaggerated scale on the Colorado River below the Hoover Dam site.

Comparison with St. Francis Not Justified

Nothing could be more misleading than the comparison of the St. Francis and Hoover dams and the drawing of conclusions therefrom. The St. Francis Dam was 16 ft. thick at the top, 176 ft. thick at the base of the maximum section, 205 ft. high at the location of the maximum section, and approximately 700 ft. long at the crest. The Hoover Dam will be 45 ft. thick at the top, 650 ft. thick at the base of the maximum section, 727 ft. high at the location of the maximum section, and approximately 1,180 ft. long at the crest. The central angles at the higher elevations in Hoover Dam, where arch action will be most important, will be considerably greater than those at corresponding elevations in the St. Francis Dam. The St. Francis Dam was essentially a gravity dam; the Hoover Dam will be essentially an arch dam. The St. Francis Dam was not provided with construction joints; the Hoover Dam will be provided with construction joints and the joints will be thoroughly grouted under high pressures after the heat of setting has been dissipated. The St. Francis Dam was not provided with an adequate drainage system, either at the base or within the dam; the Hoover Dam will be provided with an efficient drainage system, within the great mass of concrete as well as at the base of the structure.

Some of the abutment material at the St. Francis Dam site can be crushed in the fingers when dry. It disintegrates and falls to pieces when placed in water. The abutment material at the Hoover Dam site, placed in an accurate testing machine, withstands a compression of 8,000 lb. per sq. in., a pressure more than 18 times as great as the maximum stress in the concrete.

Some of the most eminent and conservative geologists in the country have examined the rock at the Hoover Dam site and have approved the material as satisfactory for the foundations and abutments of a dam of the size specified. Among those of international reputation who have passed on the geology of the dam site are Charles P. Berkey, M. Am. Soc. C.E., Professor at Columbia University; Warren J. Mead, Affiliate Am. Soc. C.E., Professor at the University of Wisconsin; and F. L. Ransome, Professor at the California Institute of Technology. The very fact that the canyon walls have stood with practically vertical sides throughout the ages necessary for the river to cut its bed down to the present level is *prima facie* evidence that the rock is strong and durable.

Arch Action Inevitable

In the Hoover Dam, about two-thirds of the total water load will be carried by arch action. There is no question regarding the transfer of load by arch action in such a dam. The arches must act. They cannot

help but act. Such minute openings as may exist at the construction joints after the concrete has cooled to normal temperature will be completely filled with grout. Consequently arch action will begin as soon as the reservoir begins to fill. If any openings whatsoever should exist after the grouting operations are completed they will be closed—by the deflections of the cantilevers and by the tangential deformations resulting from stress conditions within the dam—long before the water surface in the reservoir rises to such a level as to approximate full load conditions.

ARCH DESIGN THOROUGHLY CHECKED

The proportion of water load carried by arch action has been determined by the trial-load method of analysis which has been developed in the Denver Office of the U.S. Bureau of Reclamation during the last eight years. This method of analysis is not an experiment. It has been tested in many ways. It was checked against the actual measurements on the Stevenson Creek Test Dam. It was checked against measurements on a concrete model of the Stevenson Creek Test Dam. It was checked against measurements on a concrete model of the Gibson Dam. It is being checked against measurements on a plaster of paris and celite model of Hoover Dam. Anyone who questions the possibility of load being transferred to the abutments by arch action in a structure like Hoover Dam is grossly ignorant of the important developments which have been made in arch dam design and construction during the last ten years.

The factor of safety of an arch dam is not determined by the calculation of its sliding factor. The assumption of an uplift pressure varying from full reservoir head at the upstream edge of the base to zero at the downstream edge, applied to the full area of the base, and the calculation of the sliding factor on such an assumption, as was done by Mr. Gerry, would probably indicate the failure of every existing arch dam in the world. The fact that no arch dams have failed in such a way shows that the sliding factor is not a criterion on which to judge the safety of an arch dam.

SAFETY AGAINST SLIDING

However, if Mr. Gerry wishes to calculate the sliding factor for Hoover Dam—and will do so correctly—he will find that the structure is safe as a gravity dam. The sliding factor of 0.94 given in his article is not correct. The true value, calculated for the uplift conditions assumed in his article, is 0.74. Mr. Gerry did not mention the weight of the water on the upstream and downstream faces of the dam. He neglected to include this important vertical force in his calculations. This unfortunate neglect, together with his illogical comparison of the St. Francis and Hoover dams, is enough to discredit his entire article.

If the uplift pressure is assumed to act over two-thirds the area of the base, which is a reasonable and conservative assumption, as shown by a comprehensive study of all available data on this important subject, the true sliding factor is 0.60. Such a value is a very safe and conservative figure for straight gravity dams. The assumption made by Mr. Gerry, that uplift pressure is exerted over the full area of the base, is equivalent to the assumption that the entire dam is resting on water; or, in other words, that no part of the area of the base is in direct contact with the foundation rock.

CONFIDENCE IN SAFE SOLUTION

Hoover Dam is being designed in a most conservative manner and with the utmost care. Vertical compressive stresses at the upstream face of the dam exceed the water pressure at all levels. In other words, the criterion prescribed by Maurice Levy many years ago, a criterion which has generally been accepted by the leading engineers of Europe as well as by those of America as being ultra-conservative, is fulfilled at all elevations in the case of Hoover Dam. Because of the unprecedented size of Hoover Dam, many problems not heretofore encountered in dam design must be carefully investigated. These problems are being studied by means of models as well as by mathematical treatment based on physical laws. Some of the newer problems are difficult of exact mathematical solution. However, they can all be solved with a degree of accuracy which leaves no doubt regarding their maximum possible effect on the safety of the structure.

ELABORATE INVESTIGATION UNDER WAY

Special problems which are being investigated in connection with the design of Hoover Dam include the transfer of load by tangential shear; the transfer of load by twist; the non-linear distribution of stress in both arch and cantilever elements; the effects of water soaking of the concrete near the upstream face of the dam; the effects of Poisson's ratio; the effects of volumetric changes in the concrete; the effects of interior concrete temperature changes; the deformation of the foundation and abutment rock; the spreading of the canyon walls due to reservoir water pressure; the movements of the earth in the bottom of the reservoir due to the weight of the accumulated storage; the effects of earthquakes; the effects of high velocities on the concrete lining in the spillway shaft; the stresses in the tunnel lining and in the rock formations surrounding the tunnels; the hydraulic conditions of flow in the spillway and outlet structures; and the amount and effect of the air content in the spillway discharge.

The technical investigations have been under way for several years. It is anticipated that they will be brought to a satisfactory stage of completion some time during the year 1932, before actual work on the construction of the dam is begun. The results of the various investigations will be presented to the engineering profession for their information, for their discussion, and for their constructive criticism at as early a date as possible. However, there never has been and never will be any question regarding the absolute safety of Hoover Dam.

During the 30 years which have elapsed since its formation, the Bureau of Reclamation has built more than one hundred dams; many of them more than 100 ft. high, nine more than 200 ft. high, five more than 300 ft. high, and one, the Owyhee Dam, which will be completed this year, more than 400 ft. high. Probably in every case where the dam was high enough to attract attention some critic predicted that it would fail. Thus far, not a single one has failed. Hoover Dam will be no exception. It will stand as long as Black Canyon itself.

Safety of Hoover Dam

By H. M. Westergaard
Member American Society of Civil Engineers
Consulting Engineer, Bureau of Reclamation

In his article, Mr. Gerry has presented some deliberations leading him to the conclusion that Hoover Dam, designed as an arch dam by the U.S. Bureau of Reclamation, is not safe and should be replaced by a gravity dam. These deliberations possess simplicity, but are subject to criticism. Mr. Gerry misunderstands arch dams and makes an unwarranted comparison with St. Francis Dam; he discredits the careful and extensive analytical and experimental studies that have been made to assure the safety of Hoover Dam; he shows misconceptions concerning sliding factors; he argues for a gravity dam on the ground of its simplicity, evidently unaware of the fact that a gravity dam in such a canyon is as complex a structure as an arch dam. It is therefore not surprising that he should arrive at a misjudgment of the safety of the structure.

Hoover Dam an Arch Dam

Hoover Dam has been designed as an arch dam. Criticism of the design of an arch dam should presuppose an understanding of the structural action of such dams, but Mr. Gerry displays misunderstandings of some of the most elementary features involved. He shows a section and a plan of Hoover Dam with St. Francis Dam fitted in at the top and covering a part of the top arch. The radii at the tops are nearly the same. Thus there appears a similarity, but it is not good mechanics to ignore the striking differences in proportions and other conditions, which make one an arch dam and the other not an arch dam.

If the central cantilever of Hoover Dam were to act independently of the remainder of the dam, under the full water load; and if the modulus of elasticity of the concrete is assumed to be 2,000,000 lb. per sq. in., and foundation deformation is considered, the top of the cantilever would deflect about 0.437 ft. This deflection is to be compared with a corresponding deflection of the top arch. The top arch, if it were to deflect this amount under a water load—according to computations made with consideration of the deformations of the abutments—would require a pressure on the upstream face of approximately 12,100 lb. per sq. ft., equivalent to a head of water of 194 ft.

Furthermore, the total seasonal variation of temperature in the upper portion of Hoover Dam, where the thickness is not less than 45 ft., will be not more than about 13 deg. fahr. A drop of temperature of this magnitude would give the top arch a deflection at the crown equal to 0.061 ft. If a water pressure were to be added, so as to bring the total deflection up to the same total as before, 0.437 ft., the pressure required would still be approximately 10,400 lb. per sq. ft., equivalent to a head of water of 166 ft. These figures show the great relative stiffness of the arches in the upper part of Hoover Dam, as compared to the cantilevers, and they show that the possible seasonal variation of temperature will not cause arch action to cease.

Similar computations for St. Francis Dam, under the assumption that the foundations would not fail, give the following results: deflection of the central cantilever at the top under full water load, 0.058 ft.; water pressure required on the top arch to produce the same deflection, 560 lb. per sq. ft.; corresponding head of water, 9 ft.; possible seasonal variation of temperature in the top portion of the dam (which was only 16 ft. wide), 30 deg. fahr.; deflection of the top arch due to a drop of temperature of this magnitude, under the assumption that the arch would continue to function as an arch, 0.150 ft. The top arch, accordingly, would have had only a small relative stiffness even though the abutments had been satisfactory. Furthermore, a drop of temperature much less than the expected seasonal variation would put this arch out of action.

That the top arch of Hoover Dam, as designed, should be so much less affected by the seasonal change of temperature, is not surprising when one considers the fact that the total central angle of this arch is 136 deg., while the top of St. Francis Dam had a total central angle of only 78 deg. Also the great relative stiffness of the upper arches of Hoover Dam is not surprising considering the relative narrowness of the canyon. This stiffness, together with considerations of the effects of temperature and the fact that careful studies show the abutments of these arches will not be overtaxed, makes it utterly unreasonable to suppose that the arches would fail to go into action when this dam deflects. Hoover Dam, as designed, is an arch dam in an arch-dam site. St. Francis Dam was nothing of the kind. In spite of the superficial similarities noticed by Mr. Gerry, the two cases have little to do with each other.

Models and Structural Analysis

Although Mr. Gerry discredits the structural tests of models of dams, nevertheless these tests have been of great value in that they have proved that, with given conditions of stiffness of the abutments, the method of analysis of arch dams now used by the Bureau of Reclamation is effective. According to this method, which may be called the "extended method of trial loads," the arch dam is considered to consist of vertical cantilevers and horizontal arches with elastic abutments. The load is divided by trial between the arches and the cantilevers so that at each point of intersection the arch and the cantilever obtain the same deflection in the direction of the radius of the arch. But this "radial adjustment" is only the first step in the analysis. There are added adjustments for twists and for deflections in the directions of the tangents to the center lines of the arches, and thus the twisting moments and tangential shearing forces transmitted between adjacent arches or between adjacent cantilevers are taken into account.

There are technical difficulties about carrying through this complete process, but these difficulties have been overcome. With the effectiveness of this method estab-

lished by the tests of the models, it becomes possible by analysis to reach farther than could be done conveniently by such tests. It becomes possible to vary the assumptions concerning the mechanical properties of the bedrock, and thus to investigate the dam for a range of conditions of the bedrock. Furthermore, studies have been added dealing with non-linear distributions of stresses through the thickness of the dam and with a number of special actions. These extensive analytical studies in connection with the tests of models and the geological studies have supplied the needed information concerning the action of the dam and the relation of the dam to its foundations.

SLIDING FACTORS

It is useful to compute sliding factors because they summarize the properties of the dam. Mr. Gerry conceives of sliding of the dam as if a block were being pushed over a plane horizontal surface. With a rugged irregular boundary between the concrete dam and the rock foundation, actual sliding would require either that the dam be lifted up over the high points of the boundary surface, which is not possible, or that a sliding surface be formed by the breaking of the concrete or the bedrock. This breaking is not a matter of simple friction, but depends on the resistance to stresses.

COMPLEXITY OF A GRAVITY DAM

According to the notion expressed by Mr. Gerry, a gravity dam in a canyon is a simple, statically determinate structure. Thought on the subject will easily show that such is not the case. Twists and shears are transferred in a horizontal direction, and this transfer is not always a friendly influence. There will be bending of the horizontal slices, and enclosed arches will form. This complex action may be investigated by the extended method of trial loads. The required analysis is of about the same complexity as that of an arch dam. Statical indeterminateness does not in itself mean uncertainty and is not undesirable; but there would be, to begin with, an uncertainty about the action of a gravity dam in the Hoover Dam site. There would also be a varying tendency for the vertical expansion joints to open up, and the openings of the joints would affect the torsional resistances of the various units and the bending and enclosed-arch action of the horizontal elements. It is not rational to put a gravity dam in this arch-dam site.

JUDGING THE SAFETY

The phrase "factor of safety" has a definite meaning in the case of a simple structure subject to a single action. For example, one may specify a definite factor of safety for the cable of an elevator. This definite meaning is lost, however, when the structure is subject to several possible actions. A high dam is a complex structure, subject to a variety of actions, and its safety cannot be expressed by a single factor. The requirement stated by Mr. Gerry for a design with a definite factor of safety, therefore can remain plausible only to the unsophisticated; it is not applicable.

One may substitute a principle which is slightly less simple in form, but which has a closer relation to reality. I am indebted to a colleague at the University of Illinois, Prof. Hardy Cross, for the following formulation of this principle: "It is the business of the structural engineer to imagine each undesirable thing that might happen to the structure and provide against that."

In dealing with a complex structure it is useful to distinguish between primary and supplementary structural analyses, and between primary and supplementary safety. The primary structural analyses of Hoover Dam are those which have the aim of determining the most probable behavior of the dam under various influences, such as loads, variations of temperature, earthquakes of given intensity, and plastic flow of the concrete. The judgment of the primary safety is based on the results of the primary analyses. The supplementary analyses may represent a much smaller total effort than the primary analyses, but they are of great importance. They consist of examinations of possible departures from the probable behavior of the structure. If supplementary safety exists, it is judged on the basis of these supplementary analyses.

In the supplementary analyses, the statical indeterminateness of the arch dam figures as something important. A statically indeterminate structure is capable of resisting a load in more than one way. The result is a well known phenomenon—which is especially pronounced in structures like slabs or arch dams which are statically indeterminate an infinite number of times—namely, the phenomenon of redistribution of stresses or of borrowing of strength. In examining departures from the probable action, one may exaggerate the possibilities. Thus, in the case of Hoover Dam, one may imagine a complete disappearance of the resistance of the cantilevers to the horizontal loads. When it is found that the load can be resisted by the arch action alone, this result means that, under the imagined weakening of the cantilevers, the dam is still capable of borrowing strength from its own arches. Accordingly, the dam can be credited with a reserve of safety, or with supplementary safety.

ALL REASONABLE DOUBTS DISPELLED

Similarly, when in Hoover Dam the possibility of reduced arch action is exaggerated to the extent of assuming no arch action at all, and the dam is still found capable of standing up, this reserve stability, which is not generally found in arch dams, is credited to the dam as supplementary safety. Further studies of this sort, involving, for example, the consideration of torsional resistance with certain other resistances removed, lead to the same conclusion. In all of the cases the statical indeterminateness is of great advantage in that it creates supplementary safety. The combined final judgment of primary and supplementary safety is that Hoover Dam as now designed has a large margin of safety.

I have had the opportunity to observe that in developing the design of Hoover Dam the Bureau of Reclamation has maintained a policy which is significant in connection with the safety of the dam; namely, the policy of investigating every question that can be asked reasonably. Credit for this policy goes to Elwood Mead, Commissioner of Reclamation, R. F. Walter, Chief Engineer, and J. L. Savage, Chief Designing Engineer, Members Am. Soc. C.E. The assurance that has been obtained concerning Hoover Dam is to a large extent a product of this policy.

Side Lights on Highway Economics

A Neglected Phase of Motor Vehicle Transportation

By R. L. Morrison

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More and more money has been spent on the highways of the United States until now the total investment in highways and in motor transportation exceeds the total investment in railroads and rolling stock. The annual operating cost for the motor vehicles of the United States is ten times greater than the annual construction and maintenance bills for its highways. In this paper, presented before the Seventeenth Annual Conference on Highway Engineering at the University of Michigan, Professor Morrison draws forceful attention to the advantages of reducing motor-vehicle operating costs by improving the highways. He considers the economics of traveling time, of traffic lights, of road widening, and of by-pass highways, and points out the necessity for further study of these phases of highway economics.

Not many years ago engineers were inclined to believe that highway economics concerned the roads only. For instance, as long as the maintenance cost of a low-type surface was not excessive, it was believed that the economical thing to do was to retain it rather than to build a pavement, regardless of traffic conditions. Now, however, it is generally understood that roads, as a rule, are merely to serve the traffic and that costs of operation constitute the largest factor in most problems of highway economics.

The total annual expenditure for the construction and maintenance of roads and streets in the United States is about $2,000,000,000, while the annual cost of operating our 26,500,000 motor vehicles must be in the neighborhood of $20,000,000,000 a year, or ten times the cost of the highways. This operating cost is obtained by using the 1930 figures of the Highway Research Board's Committee on Highway Transportation, which give the operating cost of the average passenger automobile as 5.44 cents per mile for an annual mileage of 11,000, and commercial vehicle costs as 15.15 cents per mile. The annual mileage of commercial vehicles is not given in the report, and I have assumed it to be 15,000 miles.

If, through the improvement of highways, operating costs for the average vehicle can be reduced 10 per cent, then the annual saving will equal the total annual cost of all the roads and streets; and this is without giving any consideration at all to the immensely important item of traveling time saved, which may have a money value measurable only in terms of billions.

Unfortunately, it is impossible to proceed entirely upon the basis of economic principles even if political and legal restrictions are disregarded because, if any highway system is considered as a whole, the expenditures economically justified are usually far beyond the practical limitations of available funds. In other words, it is seldom possible to make all the improvements which would be sound investments, but it seems evident that in planning highway improvement the most important consideration is the resulting effect upon the cost of vehicle operation.

On any highway, the total cost of transportation is the cost of the road itself plus the cost of operating vehicles over it, and it is obvious that the most economical road in any given location will be the one for which the sum of these two items is the least. In order to compare alternate plans intelligently, annual costs must be used as a basis, but most formulas employed for this purpose are unnecessarily complicated.

If a piece of road is worth a certain sum today, it will be worth less a year from today, and this shrinkage in value, or depreciation, is one of the costs. A second element of cost is the interest which must be charged against the money invested in the road, regardless of actual financing methods. As the road wears out, its value decreases and the interest charge should be decreased accordingly. This may be illustrated by assuming that the construction is financed by means of serial bonds which are retired at the same rate that the road wears out. A third cost item is maintenance, while the last, and usually the largest, is operation.

If we let C represent the annual cost, D depreciation, I the average interest, M the annual maintenance cost, and O the annual cost of operation, then:

$$C = D + I + M + O$$

Considering the many assumptions which must be made, it seems hardly necessary to use a more involved formula and build up a mathematical superstructure which is not justified by the accuracy of the data upon which it is based.

VEHICLE OPERATION COSTS VARY WITH MILEAGE

The costs of vehicle operation may be divided into two classes. The first class includes fixed overhead charges such as insurance, taxes, and garage, which remain the same regardless of the number of miles traveled or the nature of the roads used. The second class includes such items as gasoline, oil, tires, and repairs, which vary with mileage and conditions of travel. Certain items, such as depreciation and driver's wages, may be in either the first group or the second, depending upon various circumstances.

In considering the economics of highway improvements, the fixed overhead costs of vehicle operation may often be disregarded entirely, or they may be included if an annual mileage per vehicle is assumed, but costs per mile, including fixed charges, mean nothing unless the annual mileage is given. For instance, a

certain car may cost 5 cents per mile if it runs 15,000 miles a year, and 35 cents per mile if it runs only 1,000 miles a year. To carry the illustration to an extreme, if it runs only 1 mile a year it might cost $300 or more per mile.

ESTIMATING THE COST OF DELAYS

The important element of time costs is the hardest to determine and can never be accurately known. When a

DELAY CAUSED BY UNWARRANTED TRAFFIC SIGNALS
Trunk Highway Traffic Held Up by Stop-and-Go Signal; No Cross Traffic

meter in a taxicab is merrily clicking while the cab is held in a traffic jam, there is no question but that the slightest delay costs money, but under ordinary circumstances it is hard to say that a single delay of five or ten minutes, or even more, has an actual monetary cost. The average trip, however, especially in congested areas, includes many small delays which, in the aggregate, waste a great deal of time, so that the only reasonable method of attack seems to be to determine the average value of vehicle time and then charge to each separate cause of delay its proportionate share of that value.

In connection with the Cook County Highway Transport Survey, the U.S. Bureau of Public Roads, in its 1925 Report, set a value of $3.00 per hour, or 5 cents per min., on the time of the average vehicle, including the time of the passengers. In connection with the New Jersey superhighway, Fred Lavis, M. Am. Soc. C.E., in the August 1930 issue of PROCEEDINGS, estimated the time of trucks to be worth 2.3 cents per min., that of light commercial vehicles, 2.1 cents per min., and that of non-commercial vehicles, 1.0 cents per min. The Ohio Highway Transportation Survey, described in the Bureau of Public Roads' Report for 1927, indicates that 55 per cent of the passenger car mileage is for business, and that on business trips the average number of persons per car is 1.8.

Thus all mileage may be converted to a business basis by assuming that all mileage is for business but that there is only one person per trip, and by saying that the time of persons not traveling on business is worth nothing. On this basis it would seem that an average for all vehicles of $1.20 per hour, or 2 cents per min., would be conservative, and that valuation of vehicle time will be used in this discussion.

It is my purpose to consider here only a few points of highway economics, and the first is the improvement of gravel roads. If we assume that a gravel road is already built and in use, then the question of paying out money for the construction of such a road is not involved, and therefore neglect of the item of interest does not affect the problem. Also, it may be reasonably assumed that a properly maintained gravel road does not wear out if the renewal of the gravel is included in the cost of maintenance, so that depreciation may be neglected.

DIFFERENT SURFACES COMPARED

One possible method of improvement is the application of a surface treatment. Assuming that the cost of maintenance of the plain gravel road is $500 per mile per year and the cost of applying and maintaining a surface treatment is $1,000 per mile per year, then the increase in annual cost for the surface treatment is $500 per mile per year.

Such data as are available indicate that the difference in the cost of operation of motor vehicles over an untreated gravel road and over a smooth surface is about 1 cent per mile for each vehicle per day, or $3.65 per year. On that basis, if the traffic is more than 137 vehicles per day, the saving in operating cost will be greater than the cost of the surface treatment. If the traffic should be, say, 400 vehicles per day, then the net saving would be ($3.65 × 400) − $500 = $960 per mile per year.

If, instead of a surface treatment, a pavement is built, then the saving in operating costs per vehicle may be about the same, but the annual cost of the surface will be more. Of course this cost will depend upon the type of pavement and other factors, but for illustration it

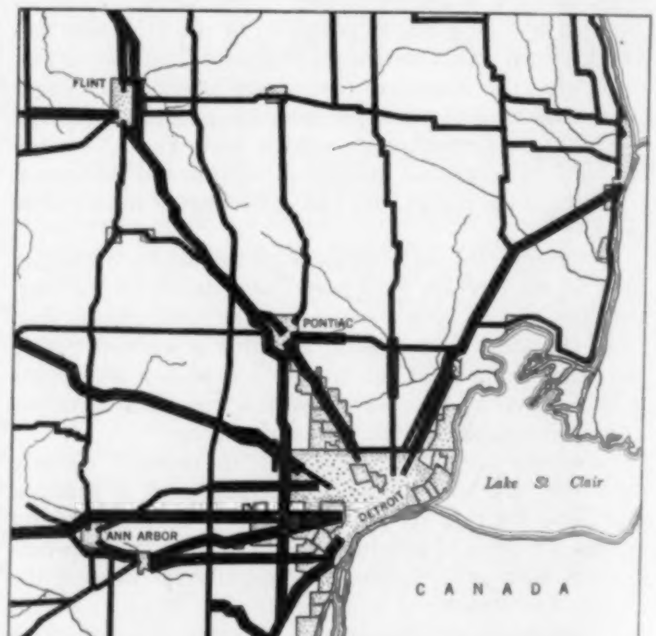

FIG. 1. BY-PASS HIGHWAYS IN MICHIGAN
Around Flint, Ann Arbor, Pontiac, and to the West of Detroit

may be assumed that the pavement costs $35,000 per mile and that at the end of 20 years it has a salvage value of $5,000. The depreciation, then, will be $30,000 ÷ 20 = $1,500 per year. Interest at 5 per cent on the

average value of $20,000 will be $1,000 per year, and the maintenance cost may be assumed to be $400, giving a total annual cost for the pavement of $1,500 + $1,000 + $400 = $2,900 per mile per year. Crediting against this the $500 maintenance cost of the gravel road, leaves a net annual cost of $2,400 per mile for the pavement. Dividing this by $3.65 gives a minimum traffic volume of about 660 vehicles per day required to justify the construction of the pavement, on the basis of these assumptions.

Incidentally it may be noted that, with the assumed cost figures, the annual cost of the pavement will be nearly $2,000 per mile per year more than the cost of a surface treatment, and that the first cost of a mile of pavement is equal to the cost of at least 20 miles of surface treatment. The cost of operation of vehicles over the two types of surface appears to be about the same, and in some cases more than 5,000 automobiles per day have been successfully operated over surface treatments when there were few heavy vehicles. Probably many miles of pavement have been built where a surface treatment would have carried the traffic satisfactorily at a fraction of the cost of the pavement.

ECONOMICS APPLIED TO TRAFFIC LIGHTS

On the state highways of Massachusetts, traffic lights are not permitted unless the traffic through the intersection amounts to at least 500 vehicles per hour, as investigations indicate that with less traffic such a light serves no useful purpose. In some other places a heavier minimum traffic is required for installation of lights.

Theoretically, half the vehicles at a light-controlled intersection will be stopped for half of the red interval. If the total light cycle is 1 min. and the traffic is 400 vehicles per hour or, say, 4,000 vehicles per day, then 2,000 vehicles will be stopped for 15 sec. each. This means a total delay of 500 car-min. a day, which, at 2 cents per min., amounts to $10 a day, or $3,650 a year. This represents an economic loss sufficient to pay the annual cost of more than one mile of pavement, or about four miles of surface treatment.

Assume another intersection with twice as much traffic, where the cost of delay would be $7,300 a year but where conditions justify the installation of a traffic signal. There are doubtless many such situations where a traffic-actuated signal would save money as well as annoyance. If a traffic-actuated signal costs $1,500 more than a fixed-cycle signal, and is used only five years, the annual additional cost for depreciation and interest will average less than $350. Assuming that the total annual maintenance cost of the traffic-actuated signal is $500 more than that of a fixed-cycle signal, a 7 per cent reduction in delays would pay for the more expensive signal and a 20 per cent saving in delays would result in a saving of nearly $1,000 per year.

FIELD OBSERVATION NEEDED

It would seem that, particularly in these days when every effort is being made to reduce costs, it would be highly profitable for every highway organization in the country to spend a few dollars in studying the simple problem of traffic-light economics through field observations and an analysis of accident records. Then facts might be substituted for assumptions in considering the advisability of erecting traffic lights, which may serve only as traffic delayers when installed without such an investigation. Of course some information of this nature is being collected by a few organizations, but the amount is pitifully small considering the vast sums involved in the problem.

What is the object of widening a road from two lanes to three or four? In most cases the fundamental justification for spending thousands of dollars a mile in widening

PROHIBITION OF PARKING EQUIVALENT TO WIDENING STREET
Only Four Traffic Lanes Now Available

roads is the resulting saving of time to the users. It may be called relief of congestion but that means the same thing, for there are very few highways in the whole country where all the traffic could not be moved through on two lanes. According to Arthur N. Johnson, M. Am. Soc. C.E., in the 1928 *Proceedings of the Highway Research Board*, a single lane will discharge approximately 2,000 vehicles per hour, at an average speed of 10 miles per hour. At that speed, a two-lane highway would carry about 100,000 vehicles in 24 hours.

It appears, therefore, that raising the average speed, or in other words saving car-minutes, is the main reason for widening a road carrying less than 100,000 vehicles per day. If this is true, then the sum which can be economically spent upon a widening project may be determined by a process similar to that outlined in the discussion of traffic lights.

FOUR LANES VERSUS TWO LANES

Assume a two-lane road carrying 10,000 vehicles daily, over which the average speed of travel, under certain traffic conditions, is 30 miles per hour, and assume that by widening the road to four lanes the average speed will be raised to 40 miles per hour. This is a reduction from 2.0 min. to 1.5 min. in the time required to travel one mile, or a saving of 5,000 car-min. per day for the total traffic. At 2 cents per min., this is a saving of $100 per day, or $36,500 per year per mile. If the annual cost of depreciation, interest, and maintenance for the additional two lanes is $3,000 per year, the net saving, due to widening, is $33,500 per mile per year.

The least known factor in this problem is the actual saving in time on a four-lane, as compared with a two-lane roadway, for various traffic volumes and conditions; the comparison previously given is based on a purely

arbitrary assumption. Until the answer to this question has been found, through research, the justifiable expenditures for widening projects are bound to be largely a matter of guesswork. And guessing in terms of millions of dollars of taxpayers' money is an expensive sport.

Some time ago there was a statement in an engineering magazine that a certain street had been widened to 80 ft. and that it was unfortunate it had not been widened to 120 ft. so that it could carry 50 per cent more traffic. That particular project cost several million dollars, and one is led to wonder if the question of spending a few millions more or less, for different widths, was determined on the assumption that traffic capacity varies directly with width. The Detroit Rapid Transit Commission and a few other organizations have collected data as to the relation between street width and traffic capacity, but there is yet much to be learned. Apparently there is also an opportunity for a more general use of what has been learned.

One thing which deserves most careful thought in this connection is the slicing off of buildings when part of the added width is to be used for parking. To prohibit parking on a street where it is now allowed is equivalent to cutting about 8 ft. from the buildings on each side, so far as providing space for moving traffic is concerned.

BY-PASS HIGHWAYS EVALUATED

What has been said about the economics of road widening is largely applicable to the construction of by-pass highways around congested areas. However, it is perhaps easier to make a reasonably accurate estimate of the time saving in the case of the by-pass route, which has the additional advantage of relieving congestion on the original route. For example, it is probably safe to say that the by-pass around Flint, Mich. (Fig. 1), saves at least 10 min. for each vehicle using it and, according to available information, the daily traffic is about 5,000 vehicles. A saving of 50,000 car-min. a day, at 2 cents each, is \$1,000 a day, or \$365,000 a year. Evidently this road pays good dividends, even without considering the relief to the streets of Flint.

One of the most difficult problems of highway administration is the proper allocation of funds between various projects, and usually the sums available are much too limited to cover all economically justified projects. From a purely economic standpoint, it is evident that limited funds should be spent where they will bring the greatest return on the investment.

Assume that a choice must be made between the construction of a by-pass, which will cost \$300,000 and produce an estimated saving of \$300,000 a year, and the improvement of a gravel road carrying an average traffic of 1,000 vehicles a day. If we assume that the annual cost of paving the gravel road, less its maintenance cost if left unpaved, is only \$2,150 a year, and the saving in operating cost is 1 cent per vehicle-mile, the net annual saving will be (\$3.65 × 1,000) − \$2,150 = \$1,500 per mile. Dividing \$300,000 by this sum, it is seen that in this case the by-pass would save as much as would 200 miles of pavement, costing perhaps \$6,000,000. Looking at it another way, the \$300,000 invested in the by-pass would save about as much as 20 times the same amount spent in paving the gravel road.

RESEARCH WOULD VERIFY ASSUMPTIONS

In this discussion assumptions have been made as to such items as the amount of differences in operating costs over different types of surfaces, the value of a car-minute, and the amount of time saved by certain improvements, and then the assumed values have been used as if they were correct, which may be far from the case. There are dozens of investigators, all over the country, working on such things as minor improvements in construction items, but only a very few appear to be studying the far more important factors involved in highway economics. Much research is needed to determine properly the factors which materially affect, or should affect, the outlay of millions. The immediate spending of comparatively large sums to shed more light on this subject would seem to be an excellent investment. The use of improperly evaluated factors where large expenditures are involved is an economic tragedy.

OUTER DRIVE, WAYNE COUNTY, MICH.
Wide Roadways Segregating Traffic Avoid Congestion and Head-on Collisions

A Modern Mexican Irrigation Development

Design and Construction of the Storage and Diversion Dams of the Calles System

By Augustin M. Valdes

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The Presidente Calles development, 6,000 ft. above sea level, is located in a section unique in soil, climatic, and economic conditions. Starting practically without data, the J. G. White Engineering Corporation, for the Comicion Nacional de Irrigacion, was able to investigate, design, and construct the initial part of the development in two years. The main storage dam on the Rio Santiago is a variable-radius concrete arch about 200 ft. high, designed with counterforted gravity abutments to take the arch shear. Calculations were based on the trial-load method. A multiple-arch diversion dam, 150 ft. high, was constructed as an overflow structure by covering the downstream face of the buttresses with a reinforced concrete slab. Ultimately 100,000 acres are to be irrigated.

THROUGH the State of Aguascalientes, from north to south, flows the Rio de Aguas Calientes, fed by its principal tributaries, the Rio Chicalote, Rio San Pedro, Rio Pabellon, Rio Santiago, and the Rio Morcinique. The principal city and capital of the state, the city of Aguascalientes, having a population of 50,000, is located on the Rio de Aguas Calientes, at the southerly limit of the Presidente Calles irrigation project, which extends north along the river for 45 km. (28 miles) to Punta Station. From north to south the area is traversed by the main line of the National Railways of Mexico between El Paso, Tex., and Mexico City, and the highway from the City of Aguascalientes to Zacatecas follows the railroad. The map in Fig. 1 shows the relation of the project to the towns and rivers within the area.

The irrigable area varies in elevation from 1,880 m. (6,166 ft.) to 1,935 m. (6,347 ft.) above sea level, and its climate is moderate and healthful. Conditions are generally favorable for successful irrigation. Within the area are several centers of population with a little over 9,000 inhabitants, the most important towns being Rincón de Romos with a population of 2,600, and Jesús Maria with 1,400.

Development of First Unit

Development of the project was begun by building the Calles Storage Dam on the Rio Santiago. This flow was then diverted to the north into a main canal, which has a capacity of 13.5 cu. m. (476 sec-ft.), by means of a diversion dam near Santiago. The main canal crosses the Rio Pabellon in an inverted siphon at Pabellon Estancia (farm) and continues northward to a proposed crossing of the Rio San Pedro at Punta Station. This

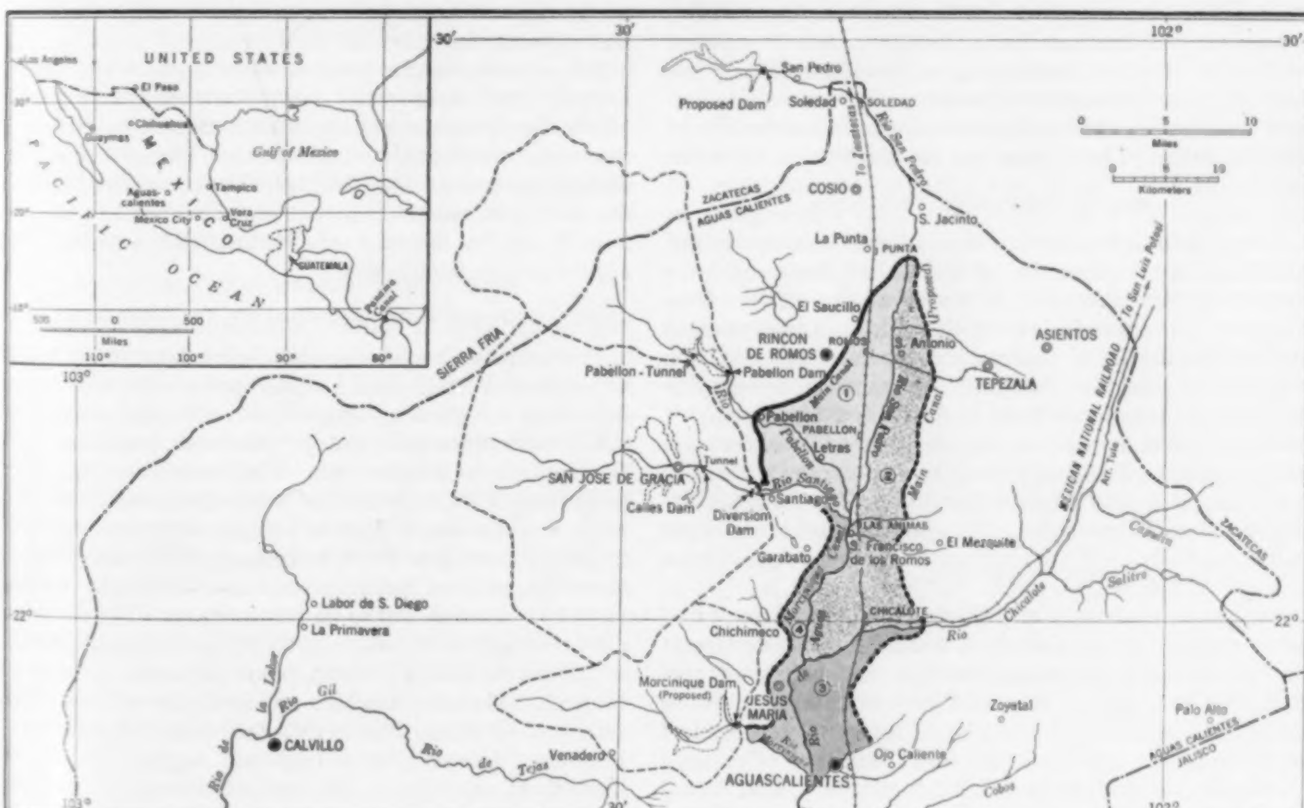


FIG. 1. Map Showing the Presidente Calles Irrigation Development

initial portion of the main canal is 28 km. long (17.4 miles), and will irrigate 9,200 hectares (22,750 acres) of land, the area marked (1) in Fig. 1.

Further expansion of the system would involve an extension of the main canal southward along the east side of the river from the Punta Station crossing, and the storage of water of the Rio Pabellon and the San Pedro to augment the supply from the Rio Santiago. Water stored on the Rio San Pedro, however, can be applied nearer by, to fertile lands lying in Zacatecas. Study has indicated the desirability of constructing a storage reservoir on the Rio Morcinique to divert it north toward the Santiago. These plans are for the future, however.

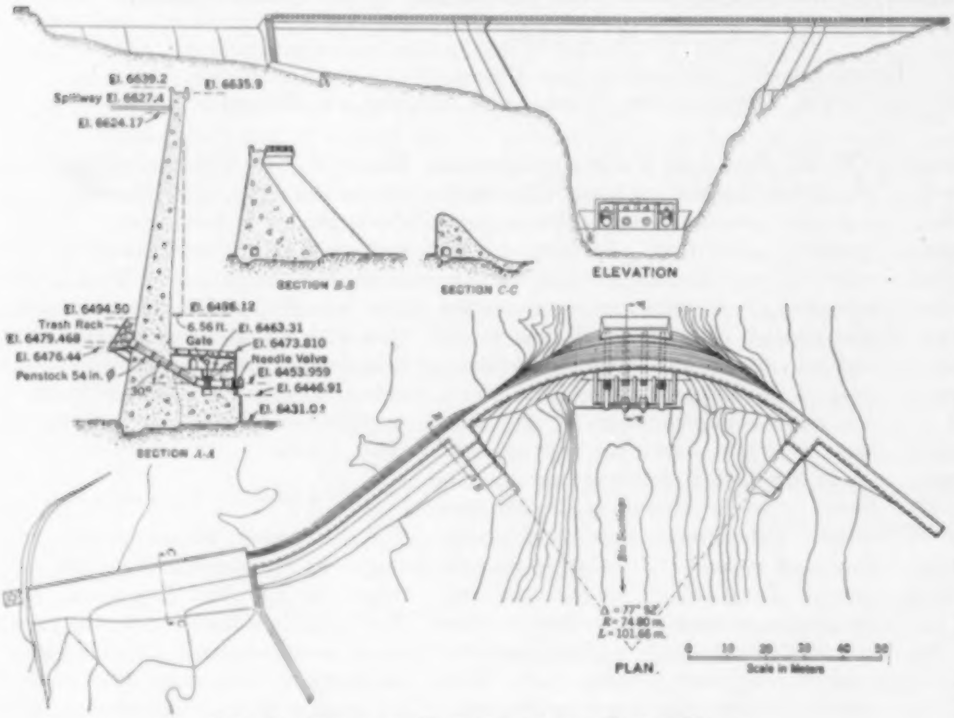


Fig. 2. Plan and Sections of the Calles Dam

PRELIMINARY INVESTIGATIONS

Surveys to determine the area of the Santiago watershed and the topography of the Calles Reservoir were begun in December 1925. Water supply studies were based on the rainfall data at the City of Aguascalientes and on the results of a permanent stream gaging station established in the Santiago Canyon. Topographic studies of the canyon itself and detailed topography of five dam sites in the canyon, together with exploration with a diamond drill at two of the sites, resulted in the selection of a safe location for the Calles Dam on excellent foundation rock. Its spillway is at elevation 2,020 m. (6,625.6 ft.) above sea level, and it provides a storage of 340,000,000 cu. m. (275,000 acre-ft.).

All property lines in the Santiago Valley were located and mapped, as was also the town of San José de Gracia in the center of the reservoir area. A system of rectangular coordinates was laid out to cover the entire irrigable area and, after careful adjustment, was marked with concrete monuments and standard Comicion Nacional de Irrigacion (C.N.I.) plates. The initial monument at Las Animas Station was assumed as K 52 N 30 E, for convenience, and all other monuments were similarly marked in accordance with their kilometer distance from this original monument. East and west lines were run each 3 km.; and north and south parallels were 2 km. apart. These rectangles formed the bases for the plane table surveys from which the topographic maps, with 1-m. contour intervals, were made. Extending from K 30 N, through the City of Aguascalientes to K 75 N, a short distance above the proposed main canal crossing on the Rio San Pedro, the area mapped covered 40,000 hectares (98,800 acres). This work was completed in September of 1927.

Two alternate locations were considered for the main canal to the north, starting at elevations 1,915 m. (6,281 ft.), and 1,935 m. (6,347 ft.), respectively. It was found that the high line included a large area of excellent land in the vicinity of Saucillo Estancia, and if taken in conjunction with a tunnel diversion, would make a better location than the low line, which had to follow a rocky cliff around the mouth of the canyon for a distance of 2 km. A diversion southward from the river, at an elevation of 1,910 m. (6,265 ft.), in the Hacienda of Santiago, was proposed but abandoned when it was found from an investigation of the Rio Morcinique that the area could be better served from that river.

Several alternative studies were made for a tunnel to take the main canal past the rough topography below the diversion site on the Rio Santiago. A bench flume was also considered around the cliffs of the canyon. Finally, a tunnel 1,400 m. (4,600 ft.) in length, was decided upon, and with it the high-line canal to the Rio San Pedro, a distance of 28 km. ($17^1/_2$ miles), was approved for construction.

CALLES STORAGE DAM DESIGNED BY TRIAL-LOAD METHOD

Preliminary designs for the Calles Dam were begun in September 1926, and included a variable-radius arch dam with a siphon spillway at one site; and a variable-radius arch dam with gravity abutments and an overflow spillway at another site. The final design, approved in January 1927, consisted of a variable-radius arch dam with counterforted gravity abutments and overflow spillway, having a total height of 63.30 m. (208 ft.) above the stream bed, or a total over-all height of 66.60 m. (219 ft.), as shown in detail in Fig. 2. The crest has a total length of 283.42 m. (930 ft.) and the arch section is 101.66 m. (333 ft.) from point of curve to point of tangent. The arch analysis was made by me, under the direction of Julian Hinds, M. Am. Soc. C.E., Resident Engineer, following the trial-load method of C. H. Howell, M. Am. Soc. C.E., and the late A. C. Jaquith, as explained in TRANSACTIONS, Vol. 93, page 1,191.

The trial-load method has been gradually developed.

It is based on the assumption that the complete dam is composed of systems of horizontal arches and vertical cantilevers, that each system carries a proportion of the total load, and that the deflections of the two systems are equal. A series of assumed proportional loads are applied to each system and their deflections are computed. When a proportionate loading has been found that gives equal deflections at all points for both systems, the stresses are computed and are considered to be those which will be obtained in the dam. The deflections and proportionate loads must be obtained at numerous points in each system in order to obtain approximately correct stresses.

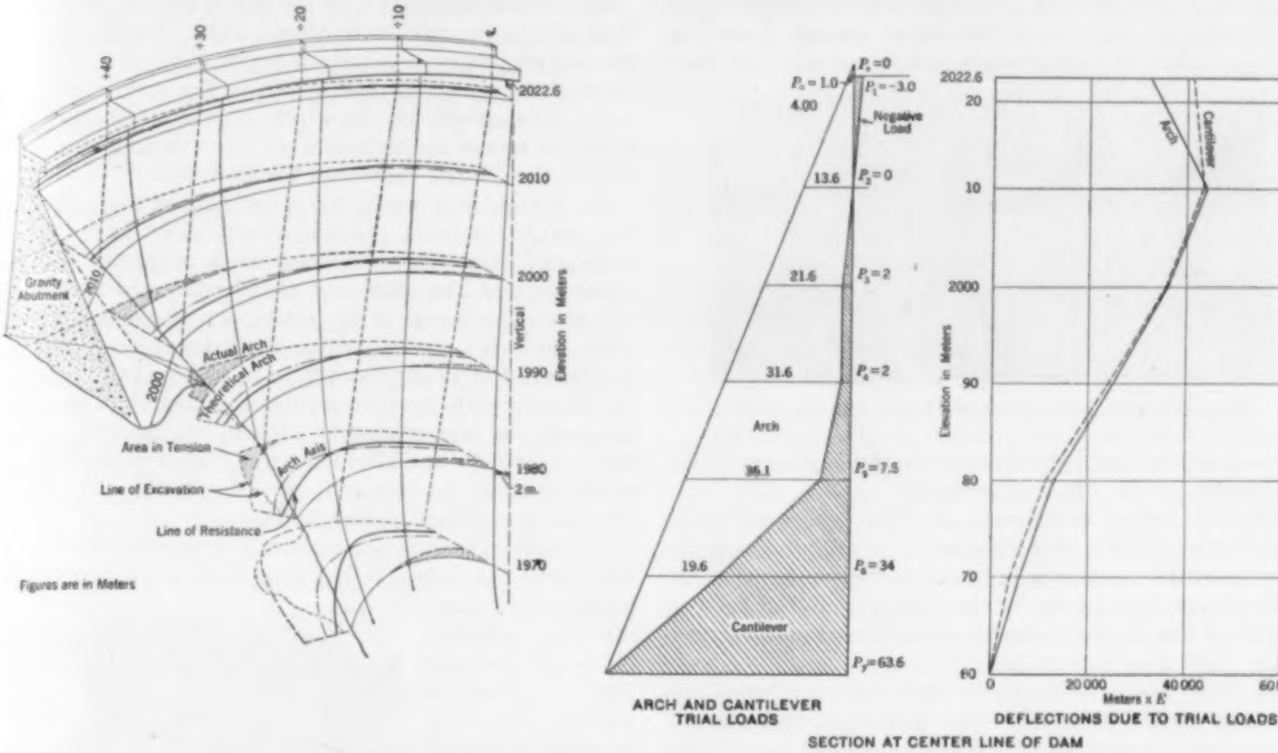


Fig. 3. Isometric Graph Showing the Theoretical Arches and Lines of Resistance
Division of Load Between Arch and Cantilever, Calles Dam

THEORETICAL ARCHES DETERMINED

There must be a definite division of the load to give equal deflections for both systems at all points. If enough trials are made, equal deflections for arch and cantilever elements at all points will finally be found, deflections and stresses due to temperature changes being taken into consideration. In computing the stresses and deflections in the arches, the concrete was assumed to take no tension. The actual constructed arch at points where the resultant fell outside of the middle third was reduced by repeated trials until an arch was found in which the resultant was at all points either on or within the middle third lines. The resulting final arch usually was reasonably uniform in shape but followed no exact geometrical outline. The load is assumed as applied to the constructed arch, but it is carried entirely by the interior one. In this type of dam, the top arches produce a negative load at the top of the cantilevers because these arches are under no hydraulic head. Conversely, the cantilevers produce a load in the top arches.

After a great many trials for each arch at different elevations, the deflection lines were brought together, as indicated in Fig. 3. It is obvious that, if the process were continued, a closer agreement would result. The most difficult part of the work was to adjust the loads in the upper arches and at the top of the cantilevers, as a very slight change of load makes a great change in deflection.

In the case of the arch at elevation 2,000 m., the line of resistance falls almost entirely within the middle third of the constructed arch. A number of trials were made to determine the largest enclosed arch that would act in compression, and that shown in Fig. 3 gave the best stresses. There are two points of tension—at the extrados, near the springing line, and at the intrados, in the crown. Elsewhere both the actual and theoretical intrados and extrados of the arch coincide.

From the bottom to elevation 1,990 m., the arch springs are built against the solid rock which forms the side walls of the canyon, so that the thrust is taken by the rock abutments. From elevation 1,990 m. to the top, the arch abuts against the transitions, which were expressly designed to carry the thrust to the gravity section and buttresses.

BOTTOM ARCH MOST COMPLEX

The arch at elevation 1,970 m., the bottom one, was the thickest and the hardest to analyze. It was necessary to use various assumptions and to make many trials. At first it was believed that more of the loads at this level would be carried by the arch than by the cantilever. An arch load greater at the crown and decreasing to the springing line was ultimately arrived at, which gave fairly good results.

Several important changes and improvements in

methods of analysis have been made since the article by Mr. Howell was written. Later, in the Mexico City office of the J. G. White Engineering Corporation, the effect of shear on the arches of the Calles Dam was taken into consideration. As the interior arches were completely in compression, this effect was not found to be important. Nevertheless, it is a factor and it is well

POURING THE ARCH SECTION OF THE CALLES DAM

to compute it, especially since its inclusion does not add materially to the work of analysis.

Further studies were made to take tangential-shear loads into account, but this work is still incomplete. The trial-load method was found entirely adequate for arched structures similar to the Calles Dam, but further studies of the method should result in certain advances in accuracy and time saving.

The final design of the Calles Dam includes two 66-in. Johnson needle valves for the regulation and control of the irrigation storage. It also includes two 54-in. outlets for the future development of power, should it later be found that the water supply is more than sufficient for the needs of irrigation.

CONSTRUCTION OF STORAGE DAM STARTED

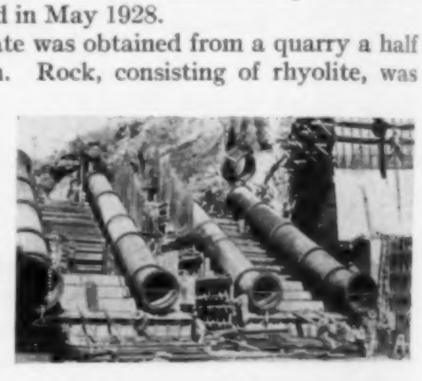
In October 1926, the first steps were taken on construction work, when a road was started from the Pabellon Station to the Calles Dam site. Work was begun at the Estancia Creek Canyon and carried on simultaneously in both directions, toward the station and toward the dam. The road was placed in operation early in January 1927, and it was completed in July of that year. It was built of clay and tepetate (hardpan), with a wearing surface of hand-broken stone, sprinkled and rolled. In its length of 19 km. (12 miles) are included one permanent bridge of seven 4.5-m. (14.75-ft.) spans, with masonry piers and a reinforced concrete slab floor, constructed at the crossing of the Rio Pabellon near Letras Estancia, and a similar but shorter bridge over the main canal of the project.

For the control of the river, two small cofferdams were constructed of clay puddle above and below excavation lines, and they were connected by a wooden flume 4 by 6 ft. in cross section, for the diversion of the low-water flow of the river. During the rainy season of 1927, work was discontinued in the canyon section to allow the floods to pass. During this time, work was started on the north and south gravity sections and on the spillway section. When the foundations were in, the flume was abandoned, and the water was permitted to pass through an opening left in the center of the arch. This opening was not closed until two months later, in order to allow for shrinkage. After it was closed, the low flow was passed through a 24-in. pipe set permanently in the dam and controlled by a gate valve at its downstream end. Before the rainy season of 1928 set in, the dam was completed and ready for use.

Excavation was begun on the north cliff in December 1926, and in the canyon in March 1927. The bottom of the canyon was excavated to a depth of 3.5 m. (11.5 ft.) below the level of the stream bed to the surface of bedrock. The cut-off trench, which runs along the heel or upstream face of the arch dam, was excavated about 2 m. (6.5 ft.) below the surface of the bedrock.

For placing concrete in the lower part of the arch section and in the south gravity section, 14-in. steel chutes suspended from steel cables were used. Concrete for the upper part of the arch and the north gravity section was placed by means of a combination of chute line and track for cars running on top of the completed part of the dam. For placing concrete in the spillway and in the south gravity section, a cableway was used, and the concrete was transported in $1^3/_4$-cu. yd. buckets. The first concrete of the Calles Dam was placed in the bottom of the canyon, for the arch section, on May 28, 1927. The last was poured in May 1928.

Concrete aggregate was obtained from a quarry a half mile from the dam. Rock, consisting of rhyolite, was handled by narrow-gage gasoline locomotives and 1-yd. dump cars on Decauville track connecting with the crushing and mixing plant above the north end of the dam. Sand was made by crushing the quarried rock at the plant for use as fine aggregate.



OUTLET PIPES, CALLES DAM

The concrete mixing plant contained two 1-yd. tilting mixers fitted with charging hoppers and gear driven by electric motors. The mixers were set under three overhead aggregate bins each having a capacity of 150 cu. m. (200 cu. yd.), the center one being for sand and the two outside ones for crushed stone.

A $1^5/_8$-in. cableway of 275-m. (900-ft.) span, with running and load lines of $^3/_4$-in. plow steel, was driven by a two-drum electric hoist. Power for operation was furnished by a semi-Diesel electric plant of two 250-hp. 6-cylinder units. Cooling water for the engine was pumped from the river to a tank made of concrete and large enough to provide water for concrete and other construction uses.

On the foundation work of the arch section, the concrete mix used was $1:2^1/_2:5$. When the crushing plant and quarry were in operation, the mix for the arch section was changed to the proportions of 1:2.4:4.8, and a water ratio of 0.88 was adopted. Due to difficulties in handling the concrete in the chutes, this ratio was increased. The mix used for the gravity section was 1:3:5.8, with a water ratio of 0.90. For the power house, parapet, trash rack, and hand-rail posts, a mix of 1:2:4 was used. The specific gravity of the concrete was found to vary from 2.10 to 2.16.

The entire foundation for the arch and gravity sections

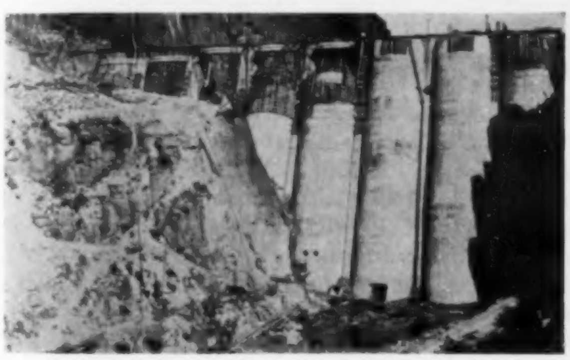
was drilled for pressure grouting. The holes were in two rows about 5 ft. apart, and staggered. Work was begun in January 1928 in placing the two 66-in. and the two 54-in. outlet pipes through the dam. In May 1928, the 66-in. gate valves and the two Johnson needle valves were installed, and in June the 54-in. valves were placed. By the first of August the outlet works were ready for operation. Provision has been made for the future installation of hydro-electric turbines on the 66-in. outlets.

MULTIPLE-ARCH DIVERSION STRUCTURE

Preliminary designs were made for various types of diversion dams at three alternative sites. These included variable-radius concrete arches with gravity abutments and concrete gravity overflow dams. Preliminary designs were also made for a masonry gravity overflow section which seemed to be cheaper than the other two types, but was abandoned because of the impossibility of securing delivery of hydraulic lime in sufficient quantity to permit completion of the dam within the available time.

A new design was then made for a multiple-arch dam, having masonry counterforts and reinforced concrete arches. The whole downstream surface of the counterforts was covered by a reinforced concrete apron, 50 cm. (20 in.) in thickness, in order to make the dam an overflow structure.

In making the analysis, of which I was in charge, a temperature drop of 10 deg. cent. from the top to the bottom of the dam was assumed. The design includes two 30-in. cast-iron outlets at elevation 1,912 m., which are controlled by two 30-in. handwheel-operated gate valves. These valves are within the interior of the dam and are connected by a gallery through the piers and under the spillway to a stairway at the north abutment.



CONSTRUCTING THE ARCHES, DIVERSION DAM

DIVERSION DAM CONSTRUCTION

A macadam road, about 2 km. in length, was constructed from the main road to the mixing plant above the diversion dam, for the hauling of cement, sand, and gravel. Another road section 500 m. (1,600 ft.) long, through heavy rock, on a grade of 11 per cent, was built to the bottom of the canyon.

Tours of inspection were made on both sides of the canyon to locate a suitable quarry site. The material on the north side was found to be very soft, badly disintegrated, and of low specific gravity. The rock on the south side was much harder, ranging in specific gravity from 2.10 to 2.50, and was considered suitable either for masonry or concrete. The quarry finally chosen was used entirely to provide the stone for masonry. Sand and gravel for concrete and mortar were obtained from a pit on the banks of the Rio Pabellon, near Pabellon Estancia about 4 miles from the diversion dam site. A very good quality of sand and gravel was excavated from this pit, although it was necessary to operate a crushing plant in order to get sufficient small-sized gravel.

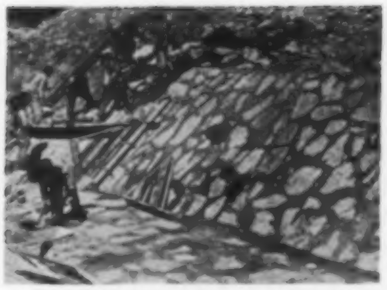
As was done in the case of the storage dam, two cofferdams were constructed for river control, and connected by a 4 by 6-ft. timber flume. The excavation was kept dry by pumping into the flume. A small amount of sheet piling was driven in the upper cofferdam to protect it from washing into the excavation. River control at this site was facilitated by storage at the Calles Dam, which was put into service in July 1928. The first excavation for the diversion dam was begun in December 1927, at the bottom of the canyon. The excavation for the masonry buttresses was squared off roughly and a level foundation prepared with concrete, averaging about 50 cm. (20 in.) in thickness. In the construction of the buttresses, stones of all sizes were used, varying from 15 cm. (6 in.) to 2 m. (6.5 ft.) in maximum thickness. They were laid on their natural bases, and the spaces between them were filled with a mixture of 1:3 cement mortar containing slaked lime equal to 15 per cent of the cement. The maximum progress made in placing masonry was 102 cu. m. (133 cu. yd.) during an 8-hr. shift.

Mixers were installed at the top of the hill, north of the dam. Concrete and mortar were chuted to the site, where they were deposited in hoppers, from which they were carried in two-wheeled push carts to the forms. Water for construction purposes was pumped from the river to a tank near the mixing plant.

The first concreting was done in May 1928, in the cut-off trench under the arches in the bottom of the canyon section. Forms for the arches and the downstream apron, which were built in sections at the carpenter shop near the site, were so constructed that they could be used several times as the work progressed. The concrete was delivered from dump carts, running on a platform along the top of the masonry buttresses and unloading into flexible chutes leading to the forms. The entire foundation for the arch section was drilled for pressure grouting, holes being placed in two rows about 5 ft. apart, and staggered, as in the case of the Calles Dam. In December 1928, the two 30-in. handwheel-operated gate valves were installed. The dam was put in operation in February 1929, when water was delivered to the Santiago Estancia.

DOWNSTREAM SLAB, DIVERSION DAM
Rests on Masonry Buttresses

The construction of the first section of the main canal,



Masonry Lining in Main Canal

which was designed to irrigate an area of 9,200 hectares (22,750 acres), marked (1) in Fig. 1, was begun in June 1927. The capacity of the canal and its structures was fixed at 13.5 cu. m. per sec. (476 sec-ft.). The design for the canal provided for a depth of water of 1.61 m. (5.3 ft.) and a base width of 9 m. (29.5 ft.). This wide shallow section was adopted because of the shallow top soil and the difficulty of excavating the underlying tepetate. Three wasteways were included in this first section, one at the inlet to the Pabellon siphon, one at the Saucillo siphon, and one at Kilometer 27, near the San Pedro siphon.

Holing Through
In the Santiago Tunnel

Five inverted siphons were designed for the crossing of creeks, the largest one, under the Rio Pabellon, having a total length of 464 m. (1,520 ft.) and a diameter of 2.40 m. (7 ft. 10 in.). This has a reinforced concrete barrel buried in the ground, with inlet and outlet transitions carefully designed to reduce losses. It has a wasteway at the inlet consisting of a concrete chute extending to the river level, the flow into which is controlled by two radial gates. The maximum head on the siphon is 19 m. (62.5 ft.). All excavation and backfilling were performed by a dragline.

Designs were also made for transferring water from the Pabellon Estancia system to the main canal and back by means of a wasteway into lower Pabellon Lake. Five checks were also included in the section, built of masonry and concrete and provided with timber flash-boards for the openings.

Main canal excavation was carried on by means of four dragline excavators. Several plans were tried to obtain more efficiency from these machines. The first plan consisted in digging both the surface material, averaging less than 40 in. in depth, and the tepetate or hardpan, which lay below it, without blasting. This plan proved to be unsatisfactory as it took a long time to excavate the hardpan, and the draglines were not fitted for that work. Tepetate, an indurated earthy material, is in many cases more difficult to excavate than solid rock.

The second plan tried consisted of making two trips with the machine, first removing the top material. Then, a gang of workmen drilled the tepetate by hand and blasted it so that it could be removed on the second trip of the machine.

In the third method, which was finally adopted, both types of material were drilled and blasted to the full depth of the canal in one operation, after which the machines had no difficulty in removing the loose material. The principal objection to this plan was the difficulty of classifying the material removed. It was also necessary to borrow on both sides of the canal to get a good loam for inside facing, in order to make the banks impervious.

All canal sections adjacent to structures, such as siphons, checks, and drops, and also certain reaches through porous material were lined with rubble masonry laid in lime mortar having a minimum thickness of 20 cm. (8 in.). A total length of 1,161 m. (3,800 ft.) of canal was thus lined.

In 1927, the possibility of diverting the Rio Pabellon into the Santiago watershed above the Calles Dam by means of a long tunnel was investigated. Several plans were considered, and several preliminary designs and estimates on alternate locations were prepared for a tunnel approximately 3 km. (2 miles) in length.

Pabellon Siphon
62-Ft. Head, Dia. 4 Ft. 10 In.

The approved plan provided for an unlined tunnel of horseshoe section, 3.40 m. (11.1 ft.) in diameter, with a section 3.20 m. (10.5 ft.) in diameter and 500 m. (1,640 ft.) long, lined with masonry and concrete. In addition, a variable-radius concrete arch diversion dam 25 m. (82 ft.) in height was provided for at a point in the Pabellon Canyon about 1 km. below the tunnel inlet.

Work on this diversion tunnel was begun in July 1928. Due to the unexpected proportion of bad ground, this tunnel is just being completed. It has been lined throughout with cement mortar masonry. Construction of the Pabellon Diversion Dam has been started but is temporarily held in abeyance.

Exploration and investigation for dam sites on the Rio Morcinique and San Pedro are continuing and the topography of both these canyons is completed. The new city of Pabellon, headquarters of the project, has been laid out and its water supply and sewerage systems are complete.

The total cost of the project to date is 9,000,000 pesos, Mexican currency, in which are included the investigations and some minor construction work on additional units. On the basis of the first unit, the area marked (1) in Fig. 1, the cost is 1,000 pesos per hectare ($200 per acre), but by the time the whole project is completed it is estimated that the cost will be reduced to 435 pesos per hectare ($87 per acre).

I wish to thank the following men for their valuable cooperation and advice: Ignacio Lopez Bancalari, Director-Manager, and Jesús Oropesa, Head of the Technical Department, both of the Comicion Nacional de Irrigacion; C. H. Howell, M. Am. Soc. C.E., Chief Engineer, and H. P. Bunger, Assoc. M. Am. Soc. C.E., Designing Engineer, both of the J. G. White Corporation; and Julian Hinds and Walter L. Drager, Members Am. Soc. C.E., who were Resident Engineers on the Presidente Calles development during its investigation, design, and construction.

Earth as a Basic Material of Construction

Purposes and Methods of Determining Its Characteristics

By Charles H. Lee

Member American Society of Civil Engineers
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A BETTER understanding of the qualities of soils and earthy materials used in engineering construction was brought to this country by Terzaghi, who had developed methods by which soil peculiarities might be predetermined by laboratory experiments. The fundamental differences between sands and clays, separately and in combination, must be understood by designers of highways, foundations, levees, hydraulic fills, storage reservoirs, and canals. Research on earthy materials has recently been much stimulated and a number of laboratories for the determination of the physical characteristics of earth have been established. By making the tests here outlined such laboratories can materially aid the engineer.

SCIENTIFIC knowledge might be thought of as a flood spreading over the various fields of human thought and activity, submerging the lowlands and gradually encroaching upon the higher elevations until even these are covered. The results of research are gradually developed and accepted until all the islands of conservatism or inertia in technical practice are inundated.

Among the civil engineering islands which up to the present time have resisted the advance of technical progress, earthwork practice is outstanding. As a basic material of construction, earth is as important as wood, steel, or concrete, if not more so. Although it is the most complex construction material with which the engineer has to deal, little is known regarding its physical and mechanical properties. Standard handbooks and reference works either entirely fail to consider earth as a material of construction or treat it vaguely. Individual judgment, arbitrary formula, or rule of thumb are still largely depended upon in design and construction. This is especially true in dealing with saturated earth, for custom does not demand that the engineer make a special preliminary investigation of groundwater conditions, or that he assume responsibility when difficulty arises.

In contrast, the failure of a competently designed superstructure, due to the unexpected behavior of the more artificial materials of construction, is rare. The modern engineer has at his command a wealth of accurate quantitative information regarding the classification, properties, and uses of these materials. The results of research and routine laboratory tests are in constant demand, and are depended upon for safe, efficient, and economic design.

The unique position which earth holds among the basic materials of construction is due partly to the fact that it is a natural substance, the use of which extends back into antiquity, partly to the lack of uniformity in its occurrence, and partly to the difficulty of accurate sampling. With the increase in size and cost of modern structures and the dependence of many people upon them for prosperity and safety, the uncertainties and unknowns surrounding its efficient use are causing increasing embarrassment to the engineer. Disintegration of highway pavements, failure of dams and retaining walls, collapse of sewers, unequal settlement of buildings, construction difficulties incident to wet excavation, and destructive slides—all are a part of recent engineering experience and may often be traced to some unexpected behavior of soil, especially to the settlement, swelling, or lateral movement of wet ground.

The lack of definite knowledge regarding earth is not confined to structural design and construction. Soil is one of the raw materials of agriculture, in which moisture control through drainage or irrigation is a vital necessity. Important problems in this field still remain unsolved. More accurate and complete soil data are needed for engineering design of drainage and irrigation systems. There is also a pressing need for a more intimate knowledge of the physical behavior of water when applied to soil, in order to attain greater efficiency in irrigation.

Earth is the container from which groundwater is extracted for economic uses. With the growth of population, this supply has been drawn on increasingly until groundwater depletion has become a matter of public concern even in humid regions. In the arid and semi-arid portions of the West an overdraft on the groundwater is particularly serious. Great sums of money are being spent on engineering investigations in an endeavor to remedy these conditions, and all such investigations have disclosed the lack of physical information regarding subsurface formations.

WHAT CONSTITUTES EARTH

The term "earth" is applied to the softer materials of the earth's surface in distinction to firm rock. Its basic constituents, the products of rock disintegration and erosion, are gravel, sand, silt, and clay, the last-mentioned occurring in both particle and colloidal form. It may also be of other origin than rock disintegration, that is, organic, diatomaceous, or volcanic. Earthy materials may occur in pure deposits, but more frequently they are found as mixtures, often combined with colloidal gel and organic matter. Common examples are sandy clay, clayey sand, soil, loam, gumbo, adobe, hardpan, peat, and muck. Ordinarily, the terms "gravel," "sand," "clay," and "peat," refer both to pure deposits and to mixtures in which the designated material predominates.

Water is present in earth to a greater or less degree, sometimes to the extent of supersaturation, as in quick-

sand and plastic clay. The presence of water, either in liquid or solid state, profoundly influences the behavior of earth and introduces the most uncertain element in its use. In connection with saturated and super-saturated materials, there is an important distinction to be made between water-bearing formations (aquifers) and beds of tight, fine-grained material (aquicludes). Aquifers are permeable and both hold and transmit water, whereas aquicludes, although porous and capable of holding water, are impermeable and do not transmit it appreciably.

SEALING CHENERY RESERVOIR BOTTOM
Leaking Areas Located by Soil Permeability Tests; Colloidal Bentonite Used in Suspension for Deposit as Sealing Agent

STATUS OF RESEARCH ON SOILS

More than fifteen years ago, the Board of Direction of the Society recognized the need for earth research by appointing a special committee "to codify present practice on the bearing value of soils for foundations and report upon the physical characteristics of soils in their relation to engineering structures." Valuable pioneering was done by this committee. It devised a scheme of classification based upon such characteristics as source of material, mineral composition, structure, porosity, water content, and texture, as determined from mechanical analysis. While such information has proved useful, much of it is laborious and costly to obtain and little is of direct use in informing the engineer how the material will behave in use.

The committee's research also emphasized the importance of colloidal material in earth, and the possibility of using the percentage of this constituent as a simple criterion of character. It has recently been shown that a colloid is not a peculiar kind of substance, but rather a collection of particles of any substance so finely divided that the force of gravity is subordinate to the forces of cohesion. Soil colloids consist of a mixture of various organic and inorganic colloids and have properties that may differ as greatly as those of the various soils of which they are composed. Intricate chemical investigations are required to identify the various colloids and to determine their degree of moisture satisfaction. Although this percentage is of vital importance, the early hope that it would serve as a simple basis for soil classification has not materialized.

More recently there has been a new mode of attack on this problem, in which laboratory research has led. Subgrade problems, arising in connection with the extensive building of highways throughout the United States, have led to intensive laboratory research of soil behavior. Comprehensive work has been done by the U.S. Bureau of Public Roads, and important contributions have been made by the Michigan State Highway Department and similar state organizations.

In 1925 the study of soil behavior was greatly stimulated by the arrival in this country of Charles Terzaghi, M. Am. Soc. C.E. His influence was reflected in the work of the Soils Laboratory of the U.S. Bureau of Public Roads, and led to the establishment of the Soil Mechanics Laboratory at the Massachusetts Institute of Technology. He presented new concepts of the characteristics and properties of various earth types and outlined a new science of foundations. His familiarity with European progress and his active presentation of a new viewpoint has stimulated engineering thought and discussion in America. Soil research from the standpoint of construction has been paralleled by the intensive work of the U.S. Department of Agriculture and various state agencies in the study of soil for agricultural uses, and the pioneer work of the Hydrologic Laboratory of the Groundwater Division, U.S. Geological Survey, in testing water-bearing materials. From all these studies are emerging a better understanding of fundamental causes and a clearer view of the future of earthwork engineering.

CHENERY RESERVOIR BOTTOM
Adobe Over Sandy Clay Subsoil

SAND AND CLAY DIFFERENTIATED

The most important contribution to modern soil research has been that of Terzaghi in bringing to light the fundamental reasons for differences between sand and clay. Contrasts in the physical properties of these materials may be briefly stated as follows:

1. Porosity

The maximum porosity of sand is slightly less than 50 per cent, while for clays it may be as great as 98 per cent.

2. Shrinkage

Sand maintains a practically constant volume during moisture changes, but clay undergoes a marked reduction of volume in drying, and swells an equivalent amount when re-wet (Fig. 1).

3. Cohesion

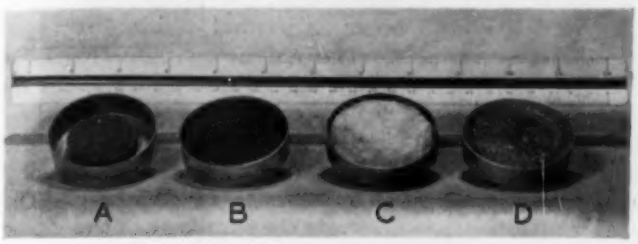
Clean sand has negligible cohesion, but clay has a remarkable amount, although it varies in degree with the moisture content.

4. Plasticity

Sand does not change its form without a change in volume, but clay is plastic, that is, it has the property of changing its form without changing its volume.

5. Compressibility

Sand is but slightly compressible under load, whereas homogeneous clay exhibits both compression when a load



AIR-DRIED PATS SHOW VOLUMETRIC SHRINKAGE

A. Bentonite C. Pumicite

B. Sandy Clay D. Adobe (Encased in Paraffin for Volume Measurement)

is applied and elastic rebound when it is removed. This property is particularly noticeable in fat clays and peat soils, and Glennon Gilboy, Jun. Am. Soc. C.E., in the February 1928 issue of PROCEEDINGS, showed it to be a property of sand when mixed with flat mica grains.

6. Rate of compression

Supersaturated or saturated sand with good drainage reaches its ultimate compression almost instantly when load is applied, while supersaturated homogeneous clay compresses very slowly under load.

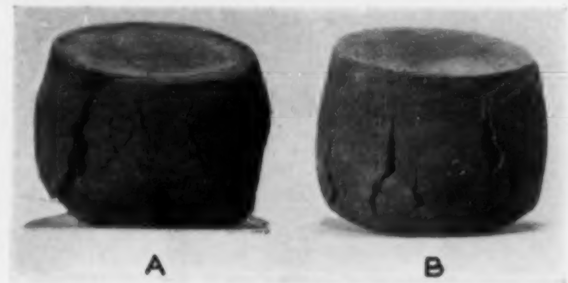
7. Permeability

Sand readily transmits water with ordinary pressure differences, but clay is relatively impermeable, although it has a wide range in transmission capacity, depending on its density.

Although apparently unrelated, the cause of these contrasting properties can be explained simply by a consideration of the size, shape, and character of the grains. Size, for example, is largely responsible for differences in porosity. This results from the fact that the behavior of larger grains, such as sand and coarse silt, is controlled by the force of gravity, while fine silt and clay particles are subject to other forces, such as adhesion and the surface tension of liquid films. When sand and silt grains settle out from suspension they roll to the bottom of the nearest depression in the sedimentary deposit and so build up a relatively dense structure. Smaller particles, however, adhere rigidly at the first point of contact and thus build up a spongy structure. Particles of colloidal size, when their electrical charge is neutralized by an electrolyte such as sea water, form spongy flocs in suspension, which, upon precipitation, build up a honeycomb structure with voids that may exceed 90 per cent of the volume. In a similar manner, all the properties of sand and clay here listed can be logically explained.

CLASSIFICATION OF EARTH

The differing physical properties of earths are merely the visible effect of corresponding differences in the size and shape of the grains, in the water content, and in the structure.



CYLINDERS OF SANDY CLAY TESTED IN COMPRESSION

Intersecting Shear Planes Appear

A. 17 Per Cent Moisture by Weight

B. 27 Per Cent Moisture by Weight

The obvious conclusion from such an analysis of soil behavior is that, by separating a given sample of earth into its constituent sizes and determining its structure, the assembled aggregate can be identified and its behavior foretold. This method has been generally followed by soil physicists and has attracted many engineering investigators. Although adapted for agricultural tests, it has led to unexpected complexities for the engineer, and has never produced usable results.

It is analogous to an attempt to determine the compressive strength of concrete by an intensive investigation of the properties of stone, sand, and cement, instead of breaking a cylinder in the testing machine. Although a knowledge of the molecular, cellular, or constituent structure of a material is desirable, it does not furnish information of immediate use to the engineer.

The more practical method and the one toward which laboratory research is now leaning, is that so successfully followed in the investigation of the standard materials of construction such as steel, wood, and concrete. By this method are catalogued the various properties of a material which have a practical significance in its use, and determination is made by test and experiment of its actual behavior. Information thus obtained can be reduced to a quantitative basis and applied directly in design.

Research in soil mechanics and its practical application in the development of standard laboratory tests has made great progress in the last ten years. A review of laboratory testing practice for subgrades, foundations, earth dams, and groundwater hydrology, reveals the following tentative list of standard tests which may be considered useful or essential in a classification and full description of the physical properties of earth:

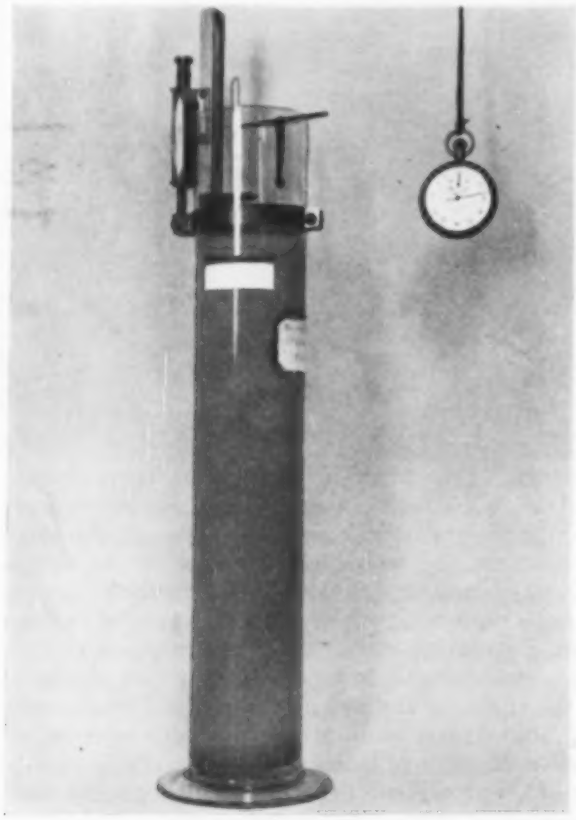
1. Mechanical analysis

A size distribution curve by itself does not ordinarily furnish data which can be directly used in engineering design. However, it serves to give a picture which is useful in connection with other tests. With the development of a satisfactory method for rapid and reasonably accurate determination, embracing the full range of sizes,

including colloidal clay, it will continue as a standard test. In conjunction with it the amount of organic material should be determined.

2. Microscopic examination

For fine-grained soils, this examination should include a determination of the shape of the grains and of the original structure of the soil—whether homogeneous, fissured, or crumbly.



HYDROMETER FOR RAPID MECHANICAL ANALYSIS OF FINES
Method Perfected by Pacific Hydrologic Laboratory

3. Colloidal fraction

Special studies of character, including amount of adsorption of water vapor are sometimes useful.

4. Moisture content

This content is measured by determining what percentage by weight the dry solid matter is of the material in its original condition.

5. Centrifugal moisture equivalent

The percentage of water retained by a saturated soil under a centrifugal force is equal to one thousand times the force of gravity. As a preliminary test this is useful in distinguishing permeable from impermeable soils, and those subject to frost heave and swelling from those which will experience only bulking.

6. Field moisture equivalent

This test gives the maximum percentage of water that a soil will absorb when its moisture content is gradually increased by the addition of water. It is useful in connection with highway subgrade work.

7. Porosity

Porosity is measured as the volume of voids, in per cent, of the total volume of the material in its original undisturbed condition.

8. Limiting porosity of loosest and densest structure

This test is useful for granular materials such as sand.

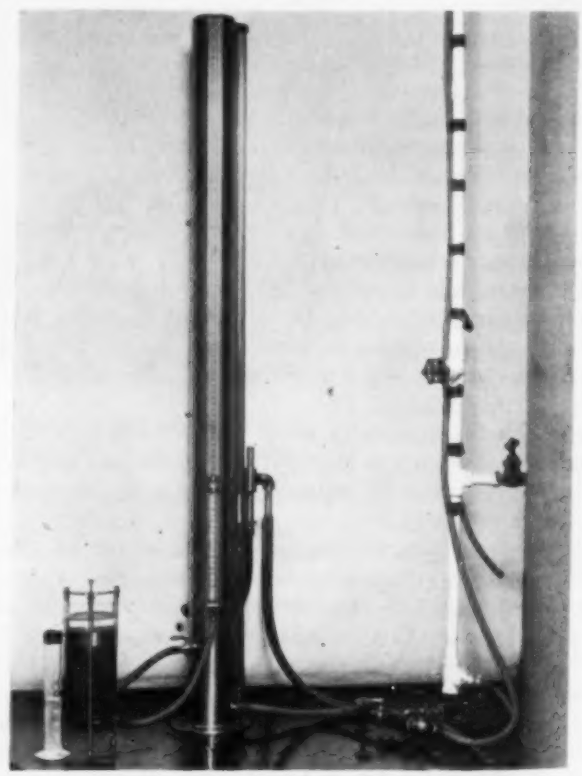
9. Plasticity

This test determines the moisture content at lower liquid and lower plastic limits, from which data the plasticity index can be computed. Its use is confined to plastic soils, since friable soils do not have plastic properties at any moisture content. This and the following test were devised by A. Atterberg, of Sweden, and since introduced by Terzaghi they have been extensively used in the United States.

10. Shrinkage determination

In this test, soil saturated to an easily workable condition is completely air dried, and its moisture content and volume are measured at the initial and final stages.

A photograph shows the shrinkage of air-dried pats of bentonite, pumicite, sandy clay, and adobe. Bentonite and pumicite both occur as natural deposits of finely divided volcanic ash. The unique swelling characteristics of bentonite result from its great age and the reduction of its particles to colloidal size by chemical decomposition, produced by weathering. Pumicite particles retain their original bulky sand-like character and are characterized by absence of shrinkage. The clay and adobe pats illustrate the shrinkage of the plastic materials ordinarily met with in engineering construction.



EQUIPMENT FOR PERMEABILITY TESTS
Core in Glass Cylinder Arranged for Upward Flow; Feed Line Descending from Vacuum Tank at Right to Remove Air from Water

From these data can be obtained values for the shrinkage limit, the shrinkage ratio, the volumetric and linear shrinkage, and the approximate specific gravity. The results of Tests 9 and 10 can be assembled conveniently on a single diagram, Fig. 1. Swelling represents water of supersaturation. Sand is rendered liquid or "quick" by

an excess of water, but clay passes through an intermediate plastic stage before becoming liquid. Due to its highly colloidal character, bentonite swells from 10 to 20 times its original or dry volume before becoming liquid. Figure 1 shows successive states of these three materials as moisture content increases from zero, together with the limiting values of each state and the plastic index or range.

11. Specific gravity of solid matter (grains)

12. Permeability

Permeability is usually expressed as a numerical coefficient representing the rate of volumetric flow through a unit cross section, acting under a hydraulic gradient of 100 per cent. A permeability-void diagram is necessary for fine-grained materials, as the coefficient varies with the degree of compression or density.

13. Compressibility and expansion

Under ordinary loads the change in volume of earth with change in load results from the decrease or increase in the volume of the voids. The data obtained from compressibility tests are ordinarily assembled as pressure-voids ratio diagrams, showing the complete cycle from no load to full load and the reverse. Clays have high compressibility and a corresponding elastic rebound due to the presence of flexible flat grains. Mixtures of mica and sand have compression diagrams similar to clays.

14. Consolidation

Consolidation is the gradual compression, due to the squeezing out of excess water, which takes place when fine-grained supersaturated soils are subjected to load. It is to be distinguished from the almost instantaneous compression which occurs when dry sand, dry clay, or saturated sand are loaded. The results of this test are expressed as a compression-time diagram. The consolidation test is of great value to the engineer since it informs him of the expected rate of consolidation and settlement of a given material under load.

15. Compressive strength

This test is applied to clay in cubic or cylindrical form and indicates the limiting pressure that the sample will carry and the inclination of the two shearing planes which appear at failure. From the results may be derived the angle of internal friction of the material and its resistance to pure shear, or cohesion, as it was termed by Coulomb. When applied to undisturbed core-drill samples with their original water content, this test yields information of great practical value in foundation work and earth dam construction.

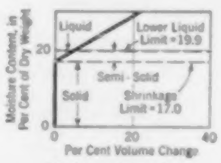
16. Resistance to shear

The coefficient of internal friction and resistance to shear may be measured directly by the use of special apparatus, several types of which have been devised. This method is superior to the compression test because it is applicable to all types of soils.

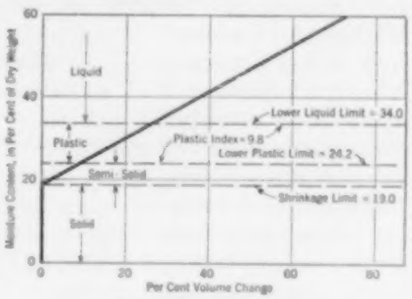
PRACTICAL DIFFICULTIES TO BE OVERCOME

This list includes practically all the properties of earth which concern the engineer. Certain of them are known to be interrelated. Future research and the accumulation of test data will undoubtedly reveal a simplified list for use in preliminary investigations or in work of small magnitude. It should also be recognized that certain properties are of importance in one field of practice and not in others, and that consequently it is necessary to consider only a limited group of properties in connection with any particular earthwork problem.

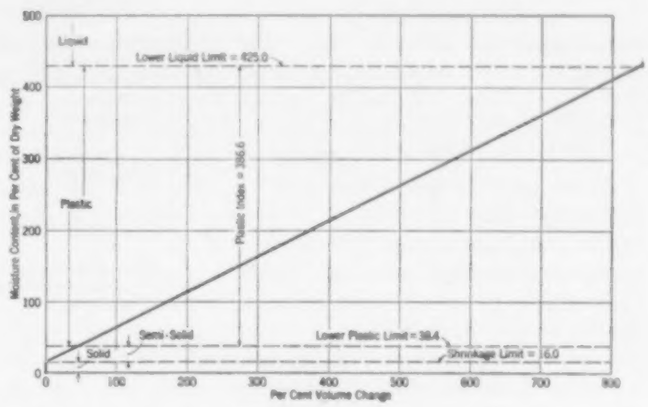
The practical application of the results of research work to soil mechanics is still in embryo, and there are obvious difficulties to be overcome. Foremost is the securing of undisturbed earth samples for testing purposes. Fortunately this problem has been encountered in other lines of technical activity, especially in the agricultural and petroleum industries, and it is now receiving active attention in the engineering field. Considerable accumulated experience and much equipment which has passed the experimental stage are available. It is believed that this problem is already well on the way to a solution.



Yellow Sand



Yellow Sandy Clay



Typical Bentonite

Fig. 1. Shrinkage Curves

Another difficulty arises from the more or less haphazard variability of sedimentary formations, which often necessitates intensive sampling in order to obtain an accurate knowledge of average soil conditions. When tests are run on a great number of samples, the cost and delay are frequently prohibitive. The solution of this problem will probably be found in the development of simple routine tests, which, in conjunction with complete control tests on type samples, will furnish sufficient data for the purpose desired at reasonable expense. It should also be recognized that, as a mass of analyzed test data accumulates, a background for judgment will be built up which will be of great value in reducing the volume of testing which might otherwise be necessary.

A third, although somewhat temporary difficulty, is the non-availability of laboratories with equipment and technic for routine testing work. The well established soil mechanics laboratories are engaged either in research or in Government routine testing work. Among these may be listed the Soil Mechanics Laboratory, Massachusetts Institute of Technology; the Soils Laboratory, Division of Tests, U.S. Bureau of Public Roads; the Hydrologic Laboratory, Groundwater Division, U.S.

Geological Survey; and soil testing departments of various state highway department laboratories.

More recently, private laboratories duplicating that at the Massachusetts Institute of Technology have been established by Metcalf and Eddy, Consulting Engineers, in Boston, and by the Hawaiian Sugar Planters Association Experiment Station, at Honolulu. The Pacific Hydrologic Laboratory at San Francisco is being equipped with apparatus selected from that in use at all three of these laboratories, and is developing laboratory technic for general soil testing work. As the demand grows, similar laboratories will doubtless be established at other points.

PRACTICAL APPLICATIONS ARE MANY

In addition to performing standard tests, earth-testing laboratories can be very useful in special research problems. An interesting example is the development of methods for increasing the impermeability of earth used in hydraulic structures through control of colloidal material. This may be accomplished either by deflocculation of the colloids already in the soil, or by the introduction of a highly colloidal material such as bentonite. Both methods have been successfully used at moderate cost under technical and laboratory control.

Bentonite is a devitrified volcanic ash geologically associated with Tertiary formations and occurring at numerous localities throughout the western states and British Columbia. It contains 70 per cent or more by weight of particles of colloidal size, and except in the presence of an electrolyte, many varieties precipitate out from suspension as a tenacious and impervious colloidal gel. Flocculation by an electrolyte such as alum or salts, occasionally in solution in natural waters, forms a precipitate of honeycomb structure which is not impervious.

PRACTICAL APPLICATIONS OF LABORATORY TESTS ON EARTH

USE OF EARTH	LABORATORY TEST	PURPOSE
		To Determine:
Highway subgrades	Liquid limit	Moisture percentage necessary for sliding
	Plastic limit	Minimum moisture percentage for plasticity
	Plastic index	Moisture range between semi-solid and liquid states
	Shrinkage limit	Moisture percentage at minimum volume
	Shrinkage ratio	Contraction and expansion with moisture change
	Centrifugal moisture equivalent (preliminary test)	Permeability and capillarity as related to frost heave and other factors
	Field moisture equivalent (preliminary test)	Shrinkage and cohesion
	Compressibility and elastic rebound	Possibility of consolidation
	Permeability	Drainage requirements
Foundations	Compressibility	Extent of consolidation
	Permeability	Rate of consolidation and quantity of groundwater to be handled from excavations
	Plasticity	Probability of plastic deformation
	Cohesion (to be supplemented by actual loading tests where possible)	Relation between settlement and diameter of loaded area
Hydraulic structures (dams and levees)	Compressibility	Extent of consolidation
	Permeability	Rate of consolidation, location and depth of adjacent borrow pits, hydraulic transmission characteristics of construction material
	Cohesion	Stability of material
	Shrinkage	Cracking characteristics of material
Surface storage reservoirs	Permeability	Location and extent of leakage
	Cohesion	Stability of margins
	Shrinkage	Tendency of bottom to crack when dry
Canals	Permeability	Location and extent of leakage
	Carrying velocity	Extent of silting or scouring
	Cohesion	Stability of banks
	Shrinkage	Tendency of bottom and sides to crack when dry
Hydraulic fills (dams, subgrades, and dredger fills)	Compressibility	Relative volumes of material originally and in fill
	Permeability	Rate of settlement
	Cohesion	Stability under load
	Shrinkage	Cracking characteristics
Underground storage reservoirs	Porosity	Total storage capacity
	Specific yield	Effective storage capacity
	Permeability	Rate of filling, leakage through confining strata, rate of compression and expansion of artesian strata due to pressure change
	Compressibility and elasticity	Storage capacity in aquifers produced by artesian pressure

Bentonite is especially useful in sealing leaky reservoir or canal bottoms. Very active leakage will carry it into the pores and effectively close them. Where the velocity of the percolating water is slow, however, the layer of precipitate must be depended upon. In such case a blanket of coarser material is desirable if the treated reservoir bottom is subject to exposure.

Laboratory test data can be practically applied in almost all branches of engineering and construction work which involve the use of earth. Such data are useful in design, in the selection of sites for structures on unconsolidated materials, in the choice of earthwork material, in the development and artificial replenishment of groundwater, and for the control of quicksand, of earth in excavations and slides, and of soil moisture in irrigation and drainage. The accompanying tabulation is sufficient to show that the field covers at least the whole range of civil engineering practice. In addition to the laboratory tests here listed, a more or less complete mechanical analysis is always useful, as is also a microscopic examination.

STANDARDIZATION IS NECESSARY

To summarize briefly, modern scientific research has not been applied to earthwork practice as it has been to the use of other materials of construction. A stage of progress has now been reached when such an application is both possible and necessary. To quote Terzaghi, "The first requirement for improving conditions consists in standardizing the methods of soil classification, and the second, in consistently applying present knowledge of soil mechanics to observations in the field." The testing laboratory is of major importance in accomplishing these results, not only by performing standard tests but also by solving special research problems.

Better Control of the Lower Mississippi

A Proposed Navigable Channel and Floodway Through the Tensas and Atchafalaya Basins

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According to present plans, control of flood heights in the lower Mississippi must be at the cost of using "fuse-plug" levees, designed to be overtopped, which may cause inundation of a third of the entire lower flood plain. To prevent this immense economic loss, Mr. Kemper proposes an independent floodway and navigable channel between the Arkansas and Red rivers, together with improvements in the Atchafalaya Basin. In so doing he submits an interesting and novel method of measuring floods and predicting flood heights. His "rate scale" should be welcomed by all students of river hydraulics.

But few people realize the difficulties that still impede the effective solution of the flood control problem of the Mississippi River. The great majority think that the passage of the Flood Control Act, in May 1928, settled the matter for all time. Only a few realize that this act was a more or less haphazard compromise, dictated by the necessity of restricting costs to a point where the administration's approval could be secured. This economic requirement subjected the Boeuf, Lower Tensas, and Atchafalaya basins—composing a full third of the entire 30,000 sq. miles of the flood plain—to conditions which, if carried out, it is believed by the inhabitants of those areas will be confiscatory.

The project adopted provides that all main river and some lower tributary levees shall be raised about 3 ft. and greatly strengthened, leaving in their present condition about 50 miles of levees immediately below the mouth of the Arkansas, at the head of the Boeuf and Tensas basins, and about 25 miles of levees along Bayou des Glaises and Old River, below the mouth of the Red River, at the head of the Atchafalaya Basin.

Fuse Plugs Objectionable

The purpose of the project—which will be realized if it is put into effect—is to have these low, weak levee sections, called "fuse plugs," fail through being overtopped when the flood rises to within 3 ft. of the tops of the levees elsewhere. The effect will be to destructively inundate the Boeuf, Lower Tensas, and Atchafalaya basins, comprising about 10,000 sq. miles, thereby protecting from floods the remainder of the flood plain—about 20,000 sq. miles. This is claimed by the authors of the project to be an economic necessity. The fact that the levees at the heads of these basins are not to be lowered or weakened was used as an argument against any liability for the damages which would result from their overtopping and failure.

Quite naturally, this viewpoint did not appeal to the property owners, and litigation resulted. The Court of Appeals has confirmed the decision of the Federal Court of the Western District of Louisiana to the effect that if floodways are made of these areas, flowage rights must be acquired. But under the Flood Control Act there is no money available with which to pay, and the report of the Corps of Engineers, made immediately before Congress adjourned in March, indicated that it will actively oppose legislation to provide such money. Work has been suspended on the proposed guide levees within the Boeuf and Atchafalaya basins, but the main river and lower tributary levees, with the exception of the proposed fuse-plug sections, are being rapidly raised and strengthened to the new grade and section. When the next flood comes, the fuse plugs will fail and the Boeuf, Lower Tensas, and Atchafalaya basins will be as effectively and completely inundated as if there had been no litigation.

Recently Lytle Brown, M. Am. Soc. C.E., Chief of Engineers, suggested modifications of the Jadwin Plan providing a concrete weir at the head of the Boeuf Basin, with a movable center and ditch 30 ft. deep leading from the weir to the head of the Atchafalaya Basin, where a similar weir would be provided. This is a step toward the plan presented in this paper, but in my opinion, it does not go far enough.

Unjust Sacrifices Demanded

The studies here recorded were made under the assumption that the court of final resort would decree that no greater duty rests upon the Boeuf and Atchafalaya basins to bear without indemnification the burden of the artificially accelerated surplus run-off from 41 per cent of the United States, than rests upon the remainder of the 30,000 sq. miles of the alluvial plain between Cape Girardeau, Mo., and the Gulf. This entire area was subject to overflow before the first levee was built in front of New Orleans in 1717.

There seems to be no foundation in justice for the assumption that a third of this area should be saddled with the entire burden of destructive floods while the remainder is protected wholly at the cost of the Federal Government. It would appear that the equity and simple justice which are guaranteed by the Constitution would require that, if the Boeuf and Atchafalaya basins are to be condemned to receive this tremendous run-off, they should be entitled to indemnification to the extent of being put at par with the remainder of the flood plain which is protected through their sacrifice.

To carry out the adopted fuse-plug project in its entirety and adequately to indemnify for all inundated areas would necessitate the expenditure by the Federal Government of probably $250,000,000 more than the present authorized sum of $325,000,000. In addition, this project permanently dedicates to floods four or five million acres of rich alluvial land, more than half of which is now in profitable use and the balance of which

can be made available for use under a competent project. It is evident, therefore, that a better plan than the adopted project is much to be desired. The study here presented was made in the hope that it would be useful in the search for such a plan.

MEASURING A FLOOD

Designers of the adopted project for flood control state that, in calculating the magnitude of floods, gage heights of the past, rather than discharge records, were relied upon. As levee extension has progressed, greater gage heights have been required to bring about given discharges, and hence the adoption of this procedure appears to involve a grave error. A glance at the gage heights at Arkansas City, below the mouth of the Arkansas, will show that they have crept up progressively from 47 ft. in 1882, the greatest flood known except perhaps that of 1927, to 60.4 ft. in the last-mentioned year; and had it been possible to confine that flood it probably would have exceeded 70 ft. The same condition prevails throughout the valley. The stage at New Orleans in 1882 was 14.9 ft., but in 1912, 1922, and 1927, it exceeded 21 ft.

Variations in discharge measurements for given stages seldom exceed a relatively small percentage and are attributable to such causes as nearby crevasses, variations in available storage areas, and length of high-water periods. A short flood has a greater velocity for a given stage than a long one.

A RATE SCALE DEVISED

In the course of the study here described, a new system was devised for measuring floods arriving at and below Arkansas City. All the water that reaches Arkansas City, except that falling on about 4,000 sq. miles near the mouths of the White and Arkansas rivers, must pass one of three stations at which discharges are measured—Helena on the Mississippi, Clarendon on the White, and Little Rock on the Arkansas. Run-off from the 4,000 sq. miles below these gage stations, which would average about 7,000 or 8,000 sec-ft., was ignored as being about necessary to compensate for evaporation and absorption by vegetation.

For nearly one hundred years discharge observations have been made and recorded by the Mississippi River Commission and other agencies. From these records standard tables of discharges have been compiled. In compiling these tables, the most recent available observations were used.

A time allowance was made for the water to travel from the several stations to Arkansas City. The discharges each day at these several stations were determined from the gage heights by applying the tables of standard discharges, which might be termed rate scales. After the proper time allowance had been made, the sum of the discharges at Helena, Clarendon, and Little Rock represented the total amount of water to arrive at the basin at the mouth of the Arkansas.

A rate scale was made to represent the water that went into storage above the Arkansas for each tenth rise on the Arkansas City gage. It was based on a storage area of 200 sq. miles at a gage height of 42.5 ft., increasing uniformly to 1,400 sq. miles at a gage height of 62.5 ft., this last being the maximum safe height at Arkansas City, as established by the Corps of Engineers.

VERIFYING THE COMPUTATION

After the rate scales were compiled, they were tested in the following manner. The flood of 1929 was the greatest that was ever carried successfully to the Gulf between levees without a crevasse. It reached a stage of 58.8 ft. at Arkansas City. By applying the rate scales to the gage heights at Helena, Clarendon, and Little Rock, during the flood of 1929, the volume in second-feet arriving each day at the mouth of the Arkansas was determined. Then, by applying the rate scale for the discharge at Arkansas City and for storage into the basin above the Arkansas, the gage heights at Arkansas City necessary to take care of this water were computed.

If the rate scales were minutely correct, this method of computation would be an exact science. The stage must rise enough to enable the combined discharge past Arkansas City and the water put into storage above the Arkansas River to equal exactly the amount to arrive there.

After calculating for each day the stages at Arkansas City necessary to take care of the flood, there was placed beside these calculated stages, in a parallel column, the actual stages recorded at Arkansas City during the flood of 1929. The accompanying Fig. 1

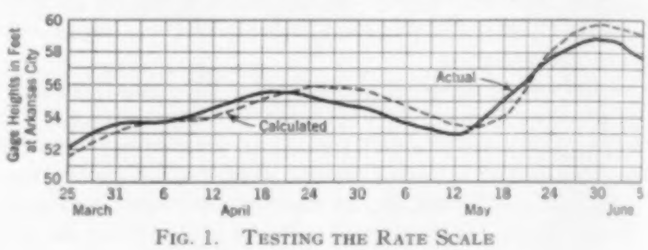


FIG. 1. TESTING THE RATE SCALE
Flood of 1929 at Arkansas City

shows, in dotted line, the calculated stages, and in solid line, the actual stages.

Although the discharge observations on which the rate scales were based were rather limited, and the areas of the storage basin for given stages were not determined with great accuracy, the conformity of the calculated and actual stages is remarkably close. The evidence is convincing that discharge measurements are dependable when used with a very moderate factor of safety. The compensation of errors no doubt takes care of much of the inaccuracy.

When applied to the flood of 1927, the rate scales indicate that a stage of 70.6 ft. would have been required to confine the flood between levees past Arkansas City.

FLOOD WATERS DISTRIBUTED

The next step is to add together the discharges at Helena, Clarendon, and Little Rock, during the flood of 1927, and to obtain the total amount of water which arrived at the basin above the mouth of the Arkansas at that time. The diagram, Fig. 2, indicates that this slightly exceeded 2,800,000 sec-ft. at its peak on April 25. But on April 21, the levees failed on the lower bank of the Arkansas, inundating the Boeuf and Tensas basins; and opposite Arkansas City, at Mound's Landing, inundating the Yazoo Basin in Mississippi.

Between April 10 and May 22, as shown in Fig. 2, about 167 million acre-ft. arrived at the basin above the mouth of the Arkansas, of which 117 million acre-ft. passed down the Mississippi River, and $54^1/_2$ million left the river through crevasses. Of this last amount about $4^1/_2$ million went into storage before April 10.

In Fig. 3 are shown the several discharges at Helena, Clarendon, and Little Rock, their sum producing the total to arrive at the basin above the mouth of the Arkansas. There is also shown an estimated discharge of 1,950,000 sec-ft. down the river past Arkansas City, at a stage of 62.5 ft., which has been established by the Corps of Engineers as the safe maximum at that point.

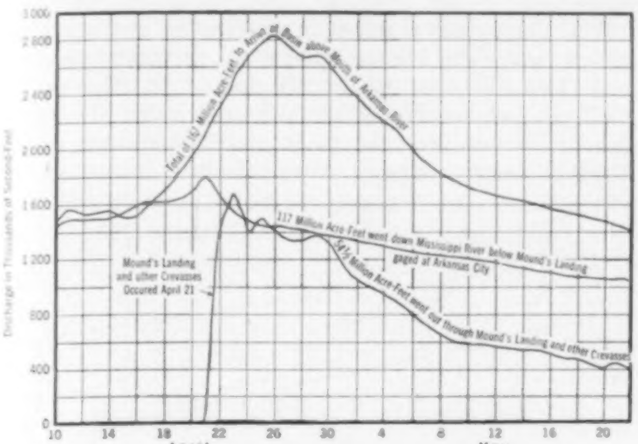


FIG. 2. DISPOSITION OF FLOOD WATERS
Flood of April and May 1927

This diagram further indicates that between April 20 and May 6, there arrived at the mouth of the Arkansas about 16 million acre-ft. of water in excess of what can be safely carried down the river when the levees are completed to the new adopted grade and section. Comparison of Figs. 2 and 3 brings to light the important fact that, in 1927, lack of provision for 16 million acre-ft. of water at the mouth of the Arkansas caused crevasses which spread 54 million acre-ft. over the country.

IMPROVING ON THE FUSE-PLUG PLAN

Since fuse-plug crevasses, when once started, do not stop discharging until the river gets below the bank-full stage, they act the same as ordinary crevasses, devastating valuable property with more than three times as much water as the excess over the safe carrying capacity of the river. It would seem that good economics would require that 16 million acre-ft. should be provided for with, say, a margin of safety of 25 per cent (or a total of 20 million acre-ft.), rather than that 54 million acre-ft. should be released through a fuse-plug crevasse, into the Boeuf Basin, a flow which must again be reckoned with at the head of the Atchafalaya Basin.

A study was first made along the following lines: an open floodway 12,000 ft. wide was tried through the Tensas Basin to begin discharging at bank-full stage, which is 42.5 on the Arkansas City gage. This plan did not prove satisfactory because the capacity of the floodway provided no margin of safety over the 1927 flood, and the backwater areas were too great.

Next, a still narrower floodway was studied with provision for excavating to a depth necessary to carry the 1927 flood with a reasonable margin of safety. With all the cost taxed against flood control, this was found to be very expensive. It suggested, however, a combination flood-control and navigation project which appears to have great merit and to be well worth the cost.

The project is shown graphically in Figs. 4 and 5. It consists of a navigation channel with a bottom width of 200 ft., and a bottom grade sloping uniformly from 9 ft. below extreme low water at the mouth of the Arkansas, to 9 ft. below extreme low water at the mouth of the Red. The side slopes are 1 on $2^1/_2$, to a height of 25 ft. above the bottom. At this point the channel becomes a floodway, widening out on a gradually rising slope to levees located 1,600 ft. each side of the center line of the canal. The top grade of these levees will slope uniformly from 63.5 on the Arkansas City gage to 60.5 on the Red River Landing (Angola) gage. This slope conforms to the new grades now being established by the Mississippi River Commission between these points.

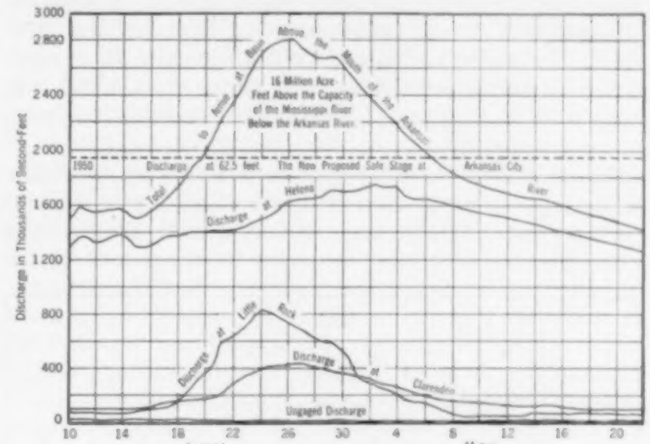


FIG. 3. SOURCES OF 1927 FLOOD
Relation to 62.5-ft. Gage at Arkansas City

By applying the rate scales previously described, it was found that, had there been such a combined navigation channel and floodway during the flood of 1927, the stage at Arkansas City would not have exceeded 60.3 ft. As the safe maximum stage is 62.5 ft., the margin of safety seems ample to provide for any flood which might reasonably be expected.

REGARDING THE SUPER-FLOOD

At this point a word about the so-called super-flood might be in order. This much-talked-of flood, to come once in 200 years, is a pure myth. It could be brought about only by excessive rainfall over the entire valley at once, but no combination of physical conditions based on past experience warrants any such occurrence. The area involved is too great and too varied in character. No prognostication is justified beyond a reasonable margin of safety over the greatest known flood.

The greatest known flood at the mouth of the Arkansas was that of 1927. It was brought about by adding to a rather severe flood on the Upper Mississippi (which followed close behind a flood on the Ohio River), floods 50 per cent greater than ever before known on the White and Arkansas rivers. There is no justification for more than a reasonable increase over the flood of

1927 at the mouth of the Arkansas; and an additional freeboard of 2.2 ft. at Arkansas City affords this reasonable margin of safety.

AN AID TO NAVIGATION

Such a combination floodway and navigation channel down the Tensas Basin, in addition to solving the flood problem in that area, without the destructive Boeuf floodway, would afford a year-round straight navigation channel with a minimum depth of 9 ft. at dead low water. This channel would extend from the Mississippi River at the mouth of Cypress Creek (just below the mouth of the Arkansas), to the Red River, a few miles above its mouth.

Space is not available here to describe in detail the advantages to navigation of such a channel as compared to the present river route. Briefly stated, the distance from the mouth of the Arkansas to the mouth of the Red River is shortened 140 miles, and a straight channel is afforded with a perpetual minimum depth of 9 ft. The channel in the main river between these points is often far less than 9 ft. deep and is very tortuous.

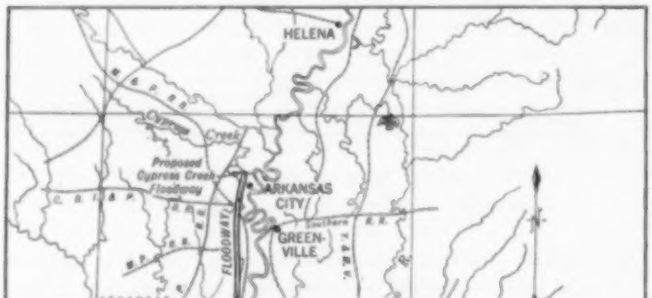


FIG. 4. PROPOSED NAVIGABLE CHANNEL AND FLOODWAY THROUGH TENSAS BASIN

For Flood Relief of the Lower Mississippi Valley

Excavation necessary for this combination navigation channel and floodway is less than one billion cubic yards, and should not cost more than 15 cents per cu. yd., or not in excess of $150,000,000. Admittedly, this is a large sum and such an expenditure in that area for flood control alone would probably not be justified, but when coupled with such a useful navigation project, its cost is amply warranted.

IN THE ATCHAFALAYA BASIN

The Atchafalaya River is strictly an outlet stream which leaves the Mississippi a short distance below the mouth of the Red River. It flows 120 miles to the Gulf, as compared with 300 miles down the Mississippi past New Orleans. At flood, the Atchafalaya carries 450,000 sec-ft., which is one-third as much as the Mississippi takes to the Gulf, and three times as much as the Red River normally delivers during flood. The Atchafalaya actually carries to the sea all the flood water of the Red River and a fifth of that which passes Natchez in the Mississippi. Since its length to the Gulf is only two-fifths the distance by way of the Mississippi, its slope is $2^1/_2$ times as great.

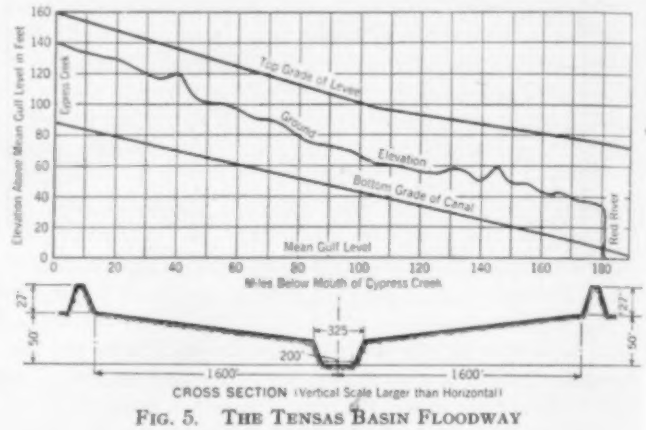


FIG. 5. THE TENSAS BASIN FLOODWAY

Profile and Section

It is an ideal location for a relief outlet. This is proved by the fact that, under the levee system, which has increased flood stages at its head 15 ft., the capacity of this stream has increased from about 50,000 sec-ft., during the Civil War, to 450,000 in 1922. The effect of this increased discharge has been to submerge thousands of acres of rich alluvial land that years ago was above flood level.

Under the adopted project it is proposed to further increase this discharge to $1^1/_2$ million sec-ft. by causing fuse-plug levee sections at the head of the Atchafalaya Basin to fail by being overtopped when the flood gets within 3 ft. of the top of the main river levees in the vicinity of the Red River's mouth. Guide levees are provided to confine the floods within the basin to some extent but, there being no provision for diverting the drainage of the adjacent lands, the effectiveness of such levees would be very limited.

In the Atchafalaya Basin, the result of putting the adopted project into effect would be to inundate, on an average of about once in $4^1/_2$ years, 5,000 of the 6,000 sq. miles which comprise the basin. Of this inundated area, about 2,400 sq. miles are low swamp and sea marsh lands, unfit for cultivation. The remainder is alluvial land of the finest quality.

It is practical and, when compared to the adopted project, economical, to increase the capacity of the Atchafalaya River to one million second-feet so as to confine a maximum flood to the river bed and the lowlands, thus saving from inundation every 4 or 5 years, several million acres of rich alluvial land. This would also save the main lines of the Southern Pacific, the Texas and Pacific, the Missouri Pacific, and the Louisiana and Arkansas railroads—New Orleans' entire rail communication with the West—which likewise will under the adopted project be inundated every 4 or 5 years. The Jefferson Highway from New Orleans to Winnipeg and the Old Spanish Trail from New Orleans to California would also be saved from inundation, as well as 600 miles of minor roads. In addition, the business of more than 500 miles of branch railroads would be preserved because their productive territory would be spared.

All told, if the floods in the Atchafalaya Basin can be confined to the river's bed and the adjacent lowlands, damages aggregating at least \$150,000,000 in this basin alone will be avoided. Such a goal is surely worth an effort.

Provisions to Safeguard the Basin

Down the Atchafalaya River, the slope to the Gulf is more than one-half foot to the mile. For the first 40 miles, to a point a short distance below the Missouri Pacific Railroad, the river runs through high land and is a single stream with levees on both banks. Below, it breaks into a great many small streams and flows through a low cypress swamp. These streams come together again at Morgan City, and for the remaining 16 miles to the Gulf, there is only a single stream channel.

Throughout the 40 miles of the upper stream, the river's capacity can be increased to a million second-feet by removing certain restricting contrivances used by Government and state agencies under the old "confinement and levees only" system to reduce the flow, and by dredging the channels. It would be necessary only to loosen the material in the channel and let the current carry it down and deposit it in the low swamp area.

To increase the cross section of the upper Atchafalaya to 100,000 sq. ft., with an average depth of 64 ft., would require the removal of about 250 million cu. yd. To loosen up this material for the current to carry downstream and deposit where it can do no harm should not cost more than 5 cents per cu. yd., or \$12,500,000. This expenditure would avoid the necessity of making floodways through the Upper Atchafalaya Basin, all of which is choice improved land traversed by three trunk railroads and the Jefferson Highway.

To compute the capacity, Kutter's formula, $V = C\sqrt{RS}$, may be used. A mean depth or value of the hydraulic radius, R, of 64 ft. would give C a value of about 125. The slope, S, is 0.0001. Assigning these values, $V = 10$. A velocity of 10 with a cross-section of 100,000 sq. ft. gives a discharge of 1,000,000 sec-ft.

The study upon which this article is based shows that, if the surplus flood water were brought down from the mouth of the Arkansas, through such a combination navigation and flood control channel as is here described, and if the maximum discharge capacity of the Atchafalaya were increased to one million second-feet, a flood such as that of 1927 could be carried safely through to the Gulf at a stage below 57.5 ft. on the Angola gage. This is 3 ft. below the top of the main river levees and affords an ample margin of safety.

The recent drought has emphatically shown the futility of striving for dependable navigation without the storage of flood waters to maintain an adequate summer flow. Legislation looking to the employment of stored water in behalf of navigation and irrigation is not far off, and it is probable that 750,000 sec-ft. is all the Atchafalaya Basin will ever be required to carry. Surely this volume will gradually grow less as the waters of the Nation are put to work.

All the preliminary details of this project have been worked out and are available. It can be shown that 1,000,000 sec-ft. can be safely carried through the Atchafalaya Basin to the Gulf, with the necessary locks to preserve adequate navigation communication, with all intercepted drainage effectively diverted, and with payment for all flowage rights, for about \$50,000,000. The adopted project budgets \$36,650,000 in the Atchafalaya Basin without paying for any flowage rights or damages, which will in all probability aggregate \$150,000,000.

The project here proposed provides for the expenditure of approximately the following amounts:

Purpose	Estimated Cost
To raise the fuse-plug levee section at the head of the Boeuf Basin	\$ 2,000,000
To construct a channel for navigation and flood control through the Boeuf Basin	150,000,000
To raise the fuse-plug section at the head of the Atchafalaya River and enlarge that stream to a capacity of 1,000,000 sec-ft., divert all drainage, pay all flowage rights, and establish navigation to the west	50,000,000
Total for proposed project	\$202,000,000
Amount budgeted in the Boeuf and Atchafalaya basins under the Jadwin Plan	47,700,000
Total additional required for the proposed project	\$154,300,000

In the report of the Special Board, \$11,050,000 was budgeted in the Boeuf Basin, but the Monroe ring levee has materially increased that amount. For the Atchafalaya Basin, \$36,650,000 was budgeted, making a minimum total of \$47,700,000 for the two basins under the adopted project.

Money Well Spent

To summarize, the addition of about \$150,000,000 to the present authorized sum of \$325,000,000 would not only avoid the expenditure of about \$250,000,000 for flowage rights or damages, but would shorten the navigable distance to the Gulf by 140 miles and afford dependable navigation from the mouth of the Arkansas to the mouth of the Red River.

It would further prevent the permanent removal from useful service, present and future, of many thousand square miles of rich alluvial land, much of it highly improved and served by railroads and modern highways. The next session of Congress will necessarily be a forum for the discussion of this intricate and but poorly understood subject of water resources, of which flood control is only a phase.

HINTS THAT HELP

Today's Expedient—Tomorrow's Rule

The minutiae of everyday experience comprise a store of knowledge upon which we depend for growth as individuals and as a profession. This department, designed to contain practical or ingenious suggestions from young and old alike, should afford general pleasure not unmixed with profit.

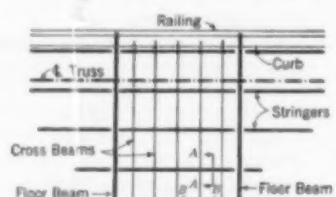
A Deck Slab for Long-Span Bridges

By Jack Davidon

Associate Member American Society of Civil Engineers
Chief Bridge Designer, State Highway Department
Jersey City, N.J.

In the design of a modern highway viaduct structure, the selection of a proper deck slab is of extreme importance. On short-span bridges, the effect of a slight variation in the slab dead load does not materially affect the design of the structure. On long spans, however, the most economical slab will yield the most economical structure, the dead load being the greatest stress-producing factor.

In recent practice, it has been the tendency to select for most long-span bridges some type of reinforced concrete slab, with or without a paving surface, the reinforcement consisting either of reinforcing bars, specially welded bar trusses, or light structural shapes. The selection of the type of reinforcement depends greatly on labor conditions in the particular locality. In several places, labor union requirements stipulate that all reinforcing bars are to be bent, assembled, and placed by union iron workers. This requirement in many instances leads to the adoption of some structural shape as the reinforcing medium, to eliminate excessive labor costs.



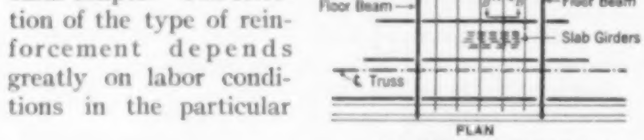


Fig. 1. Recommended Bridge Paneling, Plan and Sections

Where structural shapes are adopted, the matter of the reinforcement for transverse load distribution complicates the problem. The value of the distribution reinforcement cannot be fully realized, as it cannot be readily placed at the most effective slab depth. Furthermore, the structural shapes, as ordinarily used, have their bottom surfaces unprotected, resulting in corrosion on parts not readily accessible to painting. By capillary attraction, moisture travels up the sides of the structural shapes, seriously corroding them and destroying to a considerable extent the bond between the concrete and the steel. In addition, the introduction in the concrete of large steel surfaces with no protection at the bottom, produces large cleavage planes and weakens the transverse strength of the slab.

For these reasons, the slab illustrated in the accompanying plan and sections, Fig. 1, which show a typical bridge panel, is to be recommended. The floor beams are placed at each truss panel point; the stringers are framed into the floor beams; and light rolled cross beams are laid on top of the stringers, the top of the cross beams being at the same level as the top of the floor beams. The cross beams are so spaced that the maximum positive moment at the end slab panel is the same as that at the other panels. The maximum negative moment is then about one-half the maximum positive moment.

In the illustration is shown a typical truss panel, 25 ft. 0 in. long, on a highway 50 ft. 0 in. wide between curbs. The stringers are spaced 8 ft. 0 in. on centers; and the cross beams are spaced at 3 ft. $6\frac{1}{2}$ in., 4 ft. 3 in., 4 ft. $8\frac{1}{2}$ in., 4 ft. $8\frac{1}{2}$ in., 4 ft. 3 in., and 3 ft. $6\frac{1}{2}$ in. on centers. This slab is designed for a maximum positive dead and live moment of 85,000 in-lb. and a maximum shear of 8,500 lb., corresponding to a loading of H-20 doubled, according to the American Railway Engineering Association's Specifications of 1929. The maximum negative moment is about one-half the positive moment. Similar designs may be made for any other type of structure and loading.

The slab illustrated consists of a system of shop-riveted girders, $4\frac{3}{4}$ in. high. The top chord consists of two $1\frac{1}{4}$ by $1\frac{1}{4}$ by $\frac{1}{8}$-in. angles, $\frac{3}{4}$ in. back to back; the bottom chord, of two $1\frac{1}{4}$ by $1\frac{1}{4}$ by $\frac{1}{4}$-in. angles, $\frac{3}{4}$ in. back to back; and $1\frac{1}{8}$ by $\frac{1}{8}$-in. lacing bars connect the top and bottom chords. The lacing bars are set at an angle of about 60 deg. with the horizontal. The slab trusses are spaced about 9 in. on centers. Straps $1\frac{1}{8}$ by $\frac{1}{8}$ in. are riveted alternately at the top and bottom of the trusses, substantially as shown, acting as spacers as well as transverse reinforcement.

Fabrication of the slab trusses is very simple, as most of the material can be punched out and assembled in one operation. The erection cost is very small and the concrete form work very little, as the trusses are capable of sustaining all the construction loads. The concrete has ample room to flow around all the members, fully imbedding them and insuring a very satisfactory bond. All

sections being similar, they can be fabricated to any length or width, thus simplifying the construction.

It is recommended that the slab here described be covered with a bituminous paving surface about 2 in. thick. This top coat will serve as a wearing surface and as a waterproofing for the slab. The maintenance of such a surface on the type of base shown is very small. Any surface repairs can be made without injury to the base.

A concrete wearing surface may be ideal for a pavement on the ground, where a slight reduction in the effective depth of the slab, due to wear, is not of material consequence, but it is not well adopted to a viaduct structure where considerable vibration and temperature changes take place. The cracking up of the exposed concrete surface will eventually reduce the effective thickness of the slab, and there will be no practical means of restoring it.

The cost of the slab shown, including the additional wearing surface and exclusive of the supporting steel frame, will not exceed $10 per sq. yd.

As Cheap as Water

By C. B. Hoover

Member American Society of Civil Engineers
Superintendent, Division of Water and Sewage Disposal,
Columbus, Ohio

The water supply of a community may properly be regarded as a manufacturing business, especially in the many cases in which the raw water or crude product is unfit for domestic and industrial uses and must be subjected to a refining process or processes in which harmful bacteria, suspended solids, turbidity, and in some cases, excessive hardness, are removed.

A business of this character involves: first, the securing of an adequate supply of raw material; second, the delivery of the raw material, by gravity or pumping, to purifying and softening works in which the refining processes can be accomplished in a satisfactory manner; third, the delivery of the refined product by gravity or pumping to a distribution system which is adequate to meet maximum domestic and industrial needs, and fire-protection demands; fourth, the establishment of equitable rates for service rendered and for water consumed; and, fifth, the working out of a system of collection and accounting whereby collections for service may be efficiently made and detailed records kept of operation and maintenance costs for the various phases of the entire system.

In the larger cities of the United States, water is delivered to the consumer for from 3.5 to 4.0 cents per ton, and the average daily consumption for a city of 100,000 persons is about 42,000 tons. The average daily use in the two largest cities of the United States is about 3,750,000 tons each.

In comparing the cost of water with other commodities that are used universally and in large amounts each day, the difficulty of finding a product that is used daily in such bulk is at once apparent. The transportation of the daily tonnage of water used by New York or Chicago, represents about 75,000 carloads of 50 tons each, or 750 one-hundred-car train loads. If transported by trucks, 31,250 trucks, hauling five tons each every hour of the day, would be required.

A few comparisons of the cost of universally used commodities may be of interest, bearing in mind, of course, the differences in intrinsic value of the articles listed:

Cost per Ton, Delivered to the Consumer

Water, to small consumer	$0.04
Water, to large consumer	0.02
Sand, to large user	0.70
Gravel, to large user	0.75
Coal, to large user for steam purposes	2.00
Coal, to small user for domestic use	6.00
Cement, to large user	7.80
Cast iron, pipes, to large user	38.00
Steel, reinforcement, to large user	40.00
Gasoline, to large user	43.30
Gasoline, to small user	56.70
Bread, to large user	72.60
Steel, fabricated, to large user	80.00
Milk, to small consumer	93.00
Bread, to small consumer	160.00
Meat, to large consumer	240.00
Meat, to small consumer	600.00

There is an expression, often used, to the effect that an article is "as cheap as dirt." This should be changed to "as cheap as water."

Courtesy R. Maillart, Consulting Engineer, Geneva

Highway Bridge Over the Valtschiel, Near Andeer, Switzerland
Designed and Constructed Under the Direction of R. Maillart; 142-Ft. Span, 10-Ft. Roadway, and Arch 9.1 In. Thick at the Crown

OUR READERS SAY—

In Comment on Papers, Society Affairs, and Related Professional Interests

Twelve Principles for Flood Regulation

EDITOR: The article by Major-General Brown on "Flood Control and Channel Maintenance on the Lower Mississippi River," in the June issue, suggests to me twelve principles for the regulation of floods in the lower Mississippi.

1. The stabilization and protection of the banks is the first prerequisite of a successful system of regulation.
2. Mean and low-water regulation serve also as flood protection in so far as the improved and stabilized river channel facilitates the discharge of the flood flow.
3. Embankments built solely in the interests of agriculture, which contract the natural wide flood channel, increase the already excessive energy of the flood waters.
4. This increase in energy is detrimental because it produces a deepening of the pools and, at the same time, a shoaling of the bars below the pools without, however, producing a general lowering of the bed.

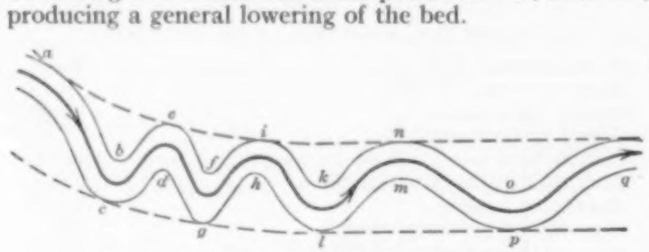


FIG. 1. THE ENVELOPE METHOD OF LEVEEING

5. Leveeing will consequently raise the high-water level.
6. Such leveeing is not a means of river regulation.
7. In determining the distance between the levees, and their location, the aim must be not only the safe discharge of the highest known flood, but also the provision of a sufficiently wide flood plain.
8. If very sharp bends must be retained the levees should not follow them, but should form an envelope of the river's meanderings, as is indicated in Fig. 1 of this discussion by (—), not by (—).
9. Even though the old levee location (—) is more favorable than the extended location (---) for the improvement of the river channel in places where low-water regulation is not feasible because of great depths, it must be borne in mind that flood protection and protection of the levees are more important than the improvement of navigability. It is therefore desirable whenever possible to change gradually from the old levee system (—) to the new (---). The sections, *a-b*, *c-d*, *e-f*, *g-h*, *i-k*, *l-m*, *n-o*, *p-q*, ..., should then be rebuilt as so-called "wing levees," extending from the top of the main levee to bank elevation in order to prevent erosion of the overflow plain at times of high water.
10. Bends are to be retained only to the extent necessary for the stabilization of the channel and the fixing of the river's course. Allowable straightening of the channel might possibly be determined by laboratory experiments.
11. Since the energy of flowing water is dissipated in pools through internal fluid friction without being available for the erosion of the downstream bars, every effort must be made to eliminate sharp bends by filling in the eroded pools and, at the same time, retracting the opposite convex banks.
12. The extent and depth of these pools, with their tremendous eddies, make it fundamentally desirable that the river itself do the work. In this connection, laboratory experiments may furnish valuable results.

HUBERT ENGELS
Professor of Engineering

Dresden, Germany
June 30, 1931

Pipes Clogged by Water-Sponge Growth

EDITOR: The article by Mr. Chester, in the June issue, suggests our experience with a growth in the pumping mains in New Brunswick, N.J. There are two lines of 20-in. pipe, one having been laid 20 years and the other 30. The growth in the pipes is mostly water sponge, which is over an inch in thickness. Both mains have a Hazen coefficient of 73, and each main has the capacity that would be expected from a 16-in. pipe. We are treating the water with chlorine, ammonia, and lime in the hope that the growth will be killed and removed from the pipes and future growths prevented.

ASHER ATKINSON, M. Am. Soc. C.E.
City Engineer

New Brunswick, N.J.
June 1, 1931

Changes in the Baltimore Pumping System

EDITOR: I found the article by Mr. Chester, in the June issue of CIVIL ENGINEERING, on Norfolk's water supply, very interesting. What Mr. Chester has to say about the passing of the steam pumps is very illustrative of what happened in Baltimore. When I took charge of the Baltimore Water Department as Chief Engineer, in 1911, there were three pumping stations. At the Mount Royal Station, there were two 20,000,000-gal. Worthington pumps; at the Eastern Pumping Station, two compound Worthington pumping engines of 10,000,000-gal. capacity; and in our service station, two 5,000,000-gal. Worthington gas-engine pumps. My first job was to put in a 30,000,000 gal. high-duty pump at the Mount Royal Station. I decided that it would be possible to discard the two 20,000,000-gal. pumps and put in modern ones, paying for them by means of the saving in the coal used, but the mayor told me that, at the time, the city would not spend any more money on the water supply.

Since then, however, a steam turbine pump has been installed, and the Eastern Pumping Station has been abandoned altogether. I recall that this station had a slippage of $33^1/_3$ per cent in its two pumps, which

were reduced to between 2 and 3 per cent by putting in new valves. All of the old Baltimore stations have by this time been replaced, and the Mount Royal Station is just in the process of being replaced by the new Vernon Pumping Station, which will have electrically driven pumps. Then Baltimore will be entirely equipped with electrically driven centrifugal pumps, the change from steam to electricity having been made in 20 years.

EZRA B. WHITMAN, M. Am. Soc. C.E.
Whitman, Requardt and Smith, Engineers

Baltimore, Md.
June 24, 1931

Cost of Movable Bridges

DEAR SIR: In the April issue, Mr. Hovey, in his article, "Movable Bridges," makes a very fair statement of the elements to be considered in determining what type of bridge should be used. However, as the article proceeds, he makes certain statements which seemingly conflict with those advanced under the head, the "Selection of Proper Type." The reasons given under this head do not seem to be justified by fact.

It is, for instance, neither proved nor shown that "the unit cost of a swing span is less than that of either a bascule or vertical-lift span," or that "a vertical-lift bridge is less expensive than a bascule, the cost being intermediate between that for swing spans and bascules," as stated by the writer of the article. These facts can only be determined by a careful analysis of site conditions and traffic requirements, and in fairness to those who may be interested in certain types, the economical and "proper" type to be used should be determined only by this means.

EDWARD HAUPT, M. Am. Soc. C.E.
President, Strobel Steel Construction Company

Chicago, Ill.
June 1, 1931

Graduated Tapes for Engineers

TO THE EDITOR: Some interesting papers on surveying methods have appeared in CIVIL ENGINEERING. In the June issue, Jerome Fee made several observations relative to the reading of angles, which many engineers and surveyors might do well to look into. I can readily appreciate his theory that astigmatism is often the cause of accumulative errors.

He states that the mental and optical process of setting two plates to zero is different from reading an angle which has been turned. I quite agree with this theory, with the exception that I believe the problem is more a matter of the psychological attitude of the transitman than it is a question of excess of eye concentration. By saying this I do not intend to minimize the effect of eye strain as an important factor, for it does exist and has a bearing on angular work.

Psychologically, the average transitman has the feeling that reading angles of even degrees is easier than those involving minutes and seconds. Actually, there is no difference in reading any angle, as the problem simply involves the coincidence of a line on the vernier with a line on the plate. I feel that most transitmen of reasonable intelligence can be shown that their apparent fear of odd angles is a fallacy.

For a number of years, I have been wondering why engineers' tapes are always graduated in such a manner as to exhibit the figures to the eye upside down. Ordinarily, a head chainman, who is right-handed, holds the tape in his left hand and the plumb-bob in his right hand. Under these conditions, the figures of all tapes with which I have had experience appear inverted. I took this question up with a representative of one of the most prominent tape manufacturers in this country, and his reply was that the tapes are made to suit the average demand of the men who have to use them, and that I was the only one who, to his knowledge, had ever censured this feature of inverted tape figures.

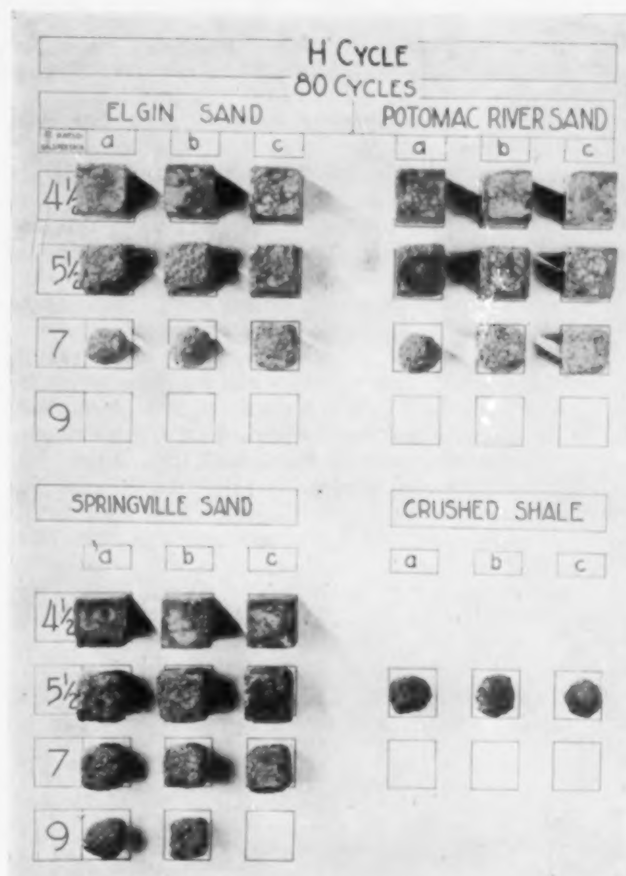
Can it be that engineers and surveyors are so wrapped up in general problems as to overlook such a simple detail, which very often is the cause of errors in tape readings? Manufacturers would be glad to graduate tapes to any reasonable demand of the users, if they would only express themselves upon the subject.

EDMUND BRITTAN, Assoc. M. Am. Soc. C.E.
Civil Engineer and City Surveyor

New York, N.Y.
June 2, 1931

Tests on Concrete Permeability

EDITOR: The paper by Mr. McMillan, in the April issue, should leave little doubt as to the soundness and importance of his chief conclusion that, for a plastic



EFFECT OF 80 CYCLES OF FREEZING AND THAWING ON 2 BY 2-IN. MORTAR CUBES

mix, "the properties of the concrete are principally determined by the properties of the hardened paste." His excellent data on permeability and resistance to freezing and thawing are of particular interest at this

time, because of the emphasis now being placed on the durability of concrete.

The influence of the quality of the paste, as affected both by the water–cement ratio and duration of the moist-curing period, on resistance to freezing and thawing, and on permeability has been shown by recent tests made at the University of Minnesota. Some typical data from these tests may be of interest in connection with Mr. McMillan's paper.

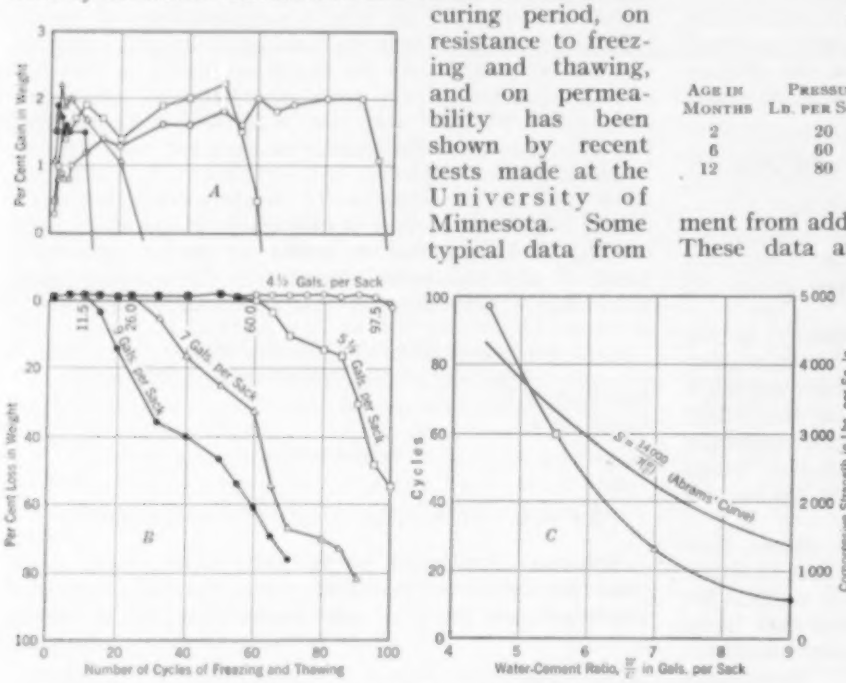


FIG. 1. TYPICAL RELATIONS RESULTING FROM ACCELERATED FREEZING AND THAWING TESTS ON 2 BY 2-IN MORTAR CUBES

The condition of 2-in. mortar cubes after 80 cycles of accelerated freezing and thawing is illustrated. The blank squares represent specimens that have reached their "end point." The freezing and thawing cycle in this case consisted of a low temperature period (0 deg. fahr. ±5 deg.) in air, and a high temperature period (70 deg. fahr. ±3 deg.) in water under a pressure of 150 lb. per sq. in. Specimens were considered to have reached their "end point" when no piece weighing more than one-sixth the original weight remained. Due to the almost complete saturation of the specimens resulting from the pressure treatment, the disintegration of freezing is much more severe than in concrete under ordinary exposure conditions. The change in weight of one group of these specimens is indicated by *A* and *B* in Fig. 1. Each point is the average for three specimens. The increase in weight is shown on an enlarged scale in *A*, and the number of cycles at which the graphs intersect the line of zero per cent loss in weight is plotted against water-cement ratio to give the graph of Section C. This, it will be noted, is quite similar to that for Abram's equation, which is:

$$S_{28} = \frac{14{,}000}{\left(7^{\frac{W}{C}}\right)}$$

where S = compressive strength at 28 days

$\frac{W}{C}$ = water–cement ratio, gallons per sack

In another series of tests, using a different and still more severe method of accelerated freezing and thawing, the average "end points" (21 specimens for each age) for moist-cured specimens were 26 and 43 cycles for ages, at first cycle, of 7 and 28 days, respectively. This clearly indicated the increased resistance to freezing and thawing resulting from additional moist curing.

Data from another set of tests, which show improvement from additional moist curing, are given in Table I.

TABLE I. PERMEABILITY TESTS

Age in Months	Pressure Lb. per Sq. In.	Average Rate of Flow in Gal. per Sq. Ft. per Hr. Moist-Cured	Air-Cured	Ratio of Flow for Air-Cured and Moist-Cured
2	20	0.000,099	0.000,271	2.8
6	60	0.000,154	0.002,116	13.7
12	80	0.000,283	0.004,711	16.7

These data are from permeability tests on concrete specimens 4 in. high and 6 in. in diameter. The flows shown are the amounts passing into the specimens. There is also shown the average rate of flow into specimens between the 40th and 60th hours, in gallons per square foot. Each value is the average of 15 tests. The concrete of both air-cured and moist-cured specimens would be water-tight in the sense that there would be no leakage under any ordinary conditions. However, for exposed situations, the greater flows into the air-cured specimens would undoubtedly result in reduced resistance to weathering or chemical attack. The moist-cured specimens were stored at 70 deg. fahr. and 100 per cent relative humidity. The air-cured specimens were stored under water for the first 7 days and then in air in the laboratory until tested.

C. A. HUGHES
Assistant Professor of Structural Engineering
University of Minnesota

Minneapolis, Minn.
June 5, 1931

Two Basic Methods of Concrete Design

TO THE EDITOR: Even though the principles established by the data cited by Mr. McMillan, in his article in the April issue, are well known, engineers still hesitate to adopt a more scientific method of design than has been used in the past. This hesitancy may be due partly to reluctance to deviate from an established practice, and partly to fear of increasing construction costs by experimentation. Consequently, the basic problem of concrete making has been obscured by a lack of proper coordination and interpretation of the results of many independent investigations. At least two possible methods of design have been proposed, both ultimately attaining the same result. So choice between the two depends upon the scope and kind of work under consideration and the conditions affecting it.

These two methods are the water cement ratio method and the mortar-void method. Both regard freshly mixed concrete as a two-component mixture, cement and water paste being considered as one component under the water–cement ratio method, and the cement, fine aggregate, and water as one component under the mortar-void method. In both systems excess water is shown to be detrimental to the strength of concrete

because in fresh concrete it is a solid and occupies space. Then, upon hydrolysis and hydration of the cement and water, the space occupied by the excess water becomes a void. The mortar-void method is based upon the principle that the strength of the concrete depends upon the ratio of voids to cement in a given volume of concrete, and from this principle a practical, workable method of designing concrete for predetermined strength has been developed.

In his article, Mr. McMillan has shown that the strength of concrete is dependent upon proper design, satisfactory materials, and adequate mixing, placing, and curing. It follows, then, that if these conditions are fulfilled, water-tightness, resistance to destructive natural elements, and uniformity of quality will also be attained, and this should be convincing argument for the adoption of a rational, scientific method of design. Designed mixes have many advantages from the standpoint of both the designer and the builder and will result in economy and uniformity of product.

When, at the beginning of the 1930 construction season, the Illinois Division of Highways decided to adopt the weight method of proportioning concrete aggregates, it was immediately faced with the problem of selecting a rational method of designing concrete mixtures. A study of this problem indicated that the mortar-void method, developed by Arthur N. Talbot, Hon. M. Am. Soc. C.E., and Frank E. Richart, M. Am. Soc. C.E., of the University of Illinois, and supplemented by data from additional investigational work, was adapted to the working out of a large highway program, so it was put into operation.

The results of the first year's work show that a minimum predetermined strength can be obtained under normal conditions, that the strength of the concrete is more uniform, that there is a large saving in cement due to uniformity of design, and that the added inspection costs are justified. This is merely cited as an instance where the principles advocated by Mr. McMillan have been recognized and acted upon. It cannot be expected, however, that the adoption of the use of basic laws of design will eliminate all of the variations from the basic principle which will occur. As Mr. McMillan points out, the explanation of these variations must be left to future researches.

V. L. Glover
Engineer of Materials
Illinois Division of Highways

Springfield, Ill.
June 2, 1931

Importance of the Aggregate in Concrete

Editor: I am one of the engineers who has been slow to accept the water–cement ratio as a basis for proportioning concrete, owing to the belief that water and cement alone are not criteria of strength and that quantity and characteristics of the aggregate are also factors. Consequently, I was interested in Mr. McMillan's discussion, in the April issue, which recognizes that the properties of concrete are influenced by characteristics of the aggregate and that a single curve cannot represent the relation between the water–cement ratio and the strength for all aggregates.

Preliminary tests of cement and aggregate will furnish useful concrete design data, which can be used in the form of the typical water–ratio strength curve. However, I prefer to use a diagram showing the relation between cement content of mix and consistency for the range of strength and flowability, which might be needed in practice. The quantities of cement and fine and coarse aggregate needed to furnish a given strength for any necessary consistency can be noted at a glance. By this method, cement and aggregate volumes are specified, and a consistency limit can be set up for each requirement of the work. Total cement and aggregate requirements are readily computed, the engineer not being concerned with the actual quantity of mixing water used, or its origin, so long as specified proportions and the limit on consistency are met.

My experience with concrete has consistently pointed to the conclusion that, for given materials, compressive strength is in general an accurate measure of quality, not only for carrying stresses but also for resisting water penetration and normal and abnormal exposure to the weather and soil waters. Increase in cement content results in increased strength and water-tightness; and to obtain full value for such additional cement flowability should be held to the usable minimum. Permeability of concrete is not a constant value but varies with the moisture content of the concrete.

It has been found necessary to produce a concrete having a strength at 28 days of less than 2,000 lb. per sq. in. in order to obtain leakage through a $2^1/_2$-in. slab at 35 lb. per sq. in. pressure. Concretes of slightly higher content are impervious when tested upon removal from damp storage at 28 days, but may show considerable seepage after a period of storage in the air, which permits shrinkage of the cement colloids. Saturation restores the concrete to its original condition of imperviousness. Higher cement content results in a fully impervious concrete when the test specimen is thoroughly dried out. No high early-strength portland cements have been included in this work, but all cements of the high alumina type, American and European, produced more pervious concretes than regular portland cements.

G. M. Williams, M. Am. Soc. C.E.
Professor of Civil Engineering
University of Saskatchewan

Saskatoon, Canada
June 2, 1931

Deck Girders Important in Subway Construction

Dear Sir: I read with a great deal of interest the comprehensive article by Mr. Peckworth on "Constructing the World's Largest Subway Station," which appeared in the April issue of Civil Engineering. In many instances, the potential hazards and difficulties of a construction job are not appreciated because much experienced forethought in design, and care in construction have minimized them, making the completed work seem much simpler than it really is. Such was the case in this subway project.

Although the buildings adjoining this section of subway were directly underpinned against settlement, it was the lateral support of the heavy cross girders on 20-ft. centers, wedged tightly at each end against the buildings, that held them from slipping while the partially disintegrated rock (mica schist) was blasted away from a 50-ft. face within 12 in. of the building lines. This twofold use of the deck girders, as beams and as struts, proved to be very successful, as it became evident that they were taking considerable pressure from the buildings.

Attention might also be called to the heavy runner beam underslung from the lower flanges of the cross sectional plate girders. This runner beam enabled the full rock heading to be worked from net line to net line by supporting the center of each cross girder as the heading passed underneath. The fore end of the runner was supported by temporary cribbing in front of the heading, while the rear end was held by the nearest four-post center tower. As the heading advanced past each cross girder at 20-ft. intervals, the regular four-post tower was erected below the cleared deck girder, and the runner beam was moved ahead on rollers to its new position spanning the heading. It was then shored in its next position by the newly erected tower and cribbing. A 90-ft. span for the deck girders, which had to carry the heavy traffic load plus the substructures, was prohibitive.

A word might also be said about the complicated mass of subsurface structures that had to be maintained not only during the construction of the station proper but also during the process of their restoration. As the station interfered with the majority of these structures, new locations had to be found for them below the street while the old structures were maintained in their original location. This was accomplished by the cooperation of the engineers of the Board of Transportation, various public utility companies, and the contractor, who, by means of depressed bays in the subway roof, flat steel boxes instead of pipes for gas, and other such devices, finally restored all the structures in their new locations.

JOHN L. WASHBOURNE, Jun. Am. Soc. C.E.
Civil Engineer, Hart and Early Company, Inc.

New York, N.Y.
June 4, 1931

Engineering Feats of the Ancients

SIR: I read with a great deal of interest Mr. Gandolfo's article on the engineering of the ancients in the April issue of CIVIL ENGINEERING. From this paper it appears that many of our so-called modern ideas are but old ideas in a new guise. As Mr. Gandolfo has pointed out, no one knows just how far back the civilizations of ancient Chaldea and Egypt date. It is noticeable, however, that the civilization of both of these peoples had its basis in artificial irrigation. In fact, Sir William Willcocks always maintained, and to a certain extent proved, that ancient civilization never developed except in countries where agriculture was impossible without it.

The statue of an early engineer, mentioned by Mr. Gandolfo, is probably that of Gu-Dea, *patesi*, or high priest, of Lagash. It is now in the Louvre in Paris. Gu-Dea was an important man in his day, a fact of which we are aware because he said so himself. He was a great builder, and his method of recording the fact, similar to our modern method of the corner-stone, was to erect a statue of himself over the main entrance to his buildings.

Hammurabi was another great man—great as king, warrior, engineer, administrator, and law-giver. Some of the provisions of his code of laws, which survived after Alexander's conquests, might be useful to the irrigation manager of today. Among the many achievements to his credit, he was the originator of our modern filing systems, and his enormous correspondence is still almost intact. His own estimate of his work is quoted as follows:

"I have made the canal of Hammurabi a blessing to the people of Sumer and Akkad. I have distributed the waters over the desert plains. I have made the water to flow in the dry channels and given an unfailing supply to the people. I have changed desert plains into well watered lands. I have given them peace and fertility and plenty. I have made them the abode of happiness."

Besides being a good engineer, Hammurabi was also a forceful executive, as is evidenced by the following extract from a letter: "The canal was dug but it was not dug clear into Erech so that the water does not come into the city. Also the bank of the Dur-ru Canal has fallen in. This is not too much for the people at thy command to do in three days. Directly on receipt of this writing dig the canal with all the people at thy command clear into the city within three days. As soon as thou hast dug the canal, do the other work which I have commanded."

It must be admitted that the ancient engineers understood their profession. In his report to the Turkish Government on the irrigation of Mesopotamia, Sir William Willcocks said, "The same problem faced the ancient Babylonian engineers and, after taking two years to find a solution, I have come to the same solution as they did." When Cheops built his pyramid, his resident engineer staked it out with an error of only 1:18,000 in distance and only 12 sec. in azimuth, which is the more remarkable when we consider that he lived about a thousand years before recorded history.

The obelisk pictured in Mr. Gandolfo's article is larger than the one in New York. Perhaps the erection of the latter and the sum it cost the city to put it in place will be recalled. Its transport from tidewater to the site was a notable piece of work for the times, as it constituted moving a 100-ton block two miles. Yet the builder of the obelisk shown in the picture moved his monument 300 miles by water and 6 miles or more by land, then set it up without any apparatus to speak of. At Stonehenge, an even more primitive people moved the enormous blocks of stone over more difficult country, but they left no records of the feat.

Such facts make us realize that we are not as progressive as we sometimes think.

HUGH MUCKLESTON, M. Am. Soc. C.E.
Consulting Engineer

Vancouver, B.C., Canada
July 4, 1931

New Measures Needed for Traffic Control

SIR: I read with interest Mr. Halsey's article in the May issue. There is general agreement that something must be done to stop the fearful automobile casualities. Before we can do anything intelligent, however, we must know something about the causes, of which there doubtless are many. Mr. Halsey states that "the twentieth century has placed such high value on time that the motorist does not like to waste any more of it than necessary." This is a very flattering explanation as far as the average careless driver is concerned. Again, Mr. Halsey states that the enforcement of speed laws is hampered because the traffic officers are too amenable to political influence and to the wishes of the motorists themselves. But the reason for this is that the traffic officers and the average motorist realize that our present laws, rules, and regulations are misdirected and do not reach the reckless driver. In

medieval times, epidemics were fought by means of public mass meetings, prayers, and processions. We know today that such measures are not effective, but our present traffic rules are, on the whole, scarcely less medieval.

I believe the great difficulty lies in the fact that we have attempted to do by means of insurance that which can be successfully handled only by policing. The remedy is either to turn the policing and the right to formulate traffic rules over to the insurance companies, or to turn the insurance over to the police department—that is, to the public.

Recently, a friend of mine was struck by a motorist driving across an intersection at high speed. This motorist should be prosecuted for speeding and reckless driving. However, in view of a pending damage suit, the insurance agency is opposed to such prosecution, since it might indicate to the jury that their client is vindictive, and affect the outcome of the damage suit. The insurance company can hardly be blamed for not doing something that experience has taught it will hurt its case.

Comparing this country with others, we have the most crime, although we are the most prosperous, the best educated, fed, and housed. We have tried to protect ourselves against theft and robberies by insurance, and it doesn't work. If there were no robberies, the insurance companies could not exist; they have only a reasonable and not too great interest in preventing robberies. If thefts become too frequent in any area, the rates are raised.

To indemnify citizens who have been robbed and to prevent the occurrence of robberies are kindred aims and should be within the authority of the same agency, as they were some centuries ago in many European countries. The same may be said of traffic control. This may appear to be a drastic remedy, but I can see no other.

B. F. Jakobsen, M. Am. Soc. C.E.
Consulting Engineer

Los Angeles, Calif.
June 16, 1931

Needed Researches in Wind Pressures

Dear Sir: You are to be commended for the publication of the report on "Wind Bracing in Tall Steel Buildings," in the March issue. This information on wind pressures to be used in design is based on experimental observations of pressures on relatively small, flat surfaces. Obviously, although this is at present the only method possible for the determination of such loadings, there is considerable room for further detailed study. It is the wind load on prismatic structures as a whole which one wishes to know. Pressures on small rectangular prisms have as yet received but little attention from those interested in aeronautical research, for they are chiefly concerned with the discovery of shapes which offer a minimum of resistance to flowing air, rather than with shapes which are liable to offer a maximum of resistance. It would not be difficult to experiment on model prisms having rectangular shapes.

Further observations seem to be desirable in regard to the horizontal distribution of pressure. These could be easily obtained by suitably designed apparatus installed at various points along a building having sufficient height to be free from unusual distribution.

These points indicate what might be undertaken as a next step in an investigation already well started. The careful determination of loads on buildings and bridges is of greatest importance, not only from the point of view of safety, but also from that of economy. Often too little attention is given to the estimation of them.

I. F. Morrison
Professor of Applied Mechanics
Department of Civil and Municipal Engineering
University of Alberta

Edmonton, Alberta, Canada
June 8, 1931

Principles of Geodetic Survey Should Be Generally Adopted

Editor: The paper by Captain Patton, in the June issue, is most interesting, and the subject is one that is claiming the attention of leading engineers everywhere. Although the geodetic control surveys are already used in many different ways, this use is almost exclusively by governmental agencies and by the more advanced engineers. The more general use of these surveys by the rank and file of engineers is still undeveloped.

There are two reasons for this. The first is the scarcity of the control stations, although this condition is now being remedied in the United States. The other reason is the reluctance of the average field man to make more general use of simplified geodetic practice or methods. Our party chiefs, resident engineers, and instrumentmen rarely use coordinates, the advantages of which Mr. Patton has pointed out, unless they are instructed to do so. Unfortunately, even when they do use them, the coordinates are generally based upon a magnetic or an assumed meridian, with an assumed origin of coordinates, and the levels are based upon an assumed datum. Occasionally they are started from a true meridian, but the origin is generally assumed and has no reference to geographical location. These assumptions destroy much of the future value of the work.

A coordinated system, based upon one common origin and one common datum plane, to which all future surveys could easily be tied, would be of the utmost value to any country. Although it may be 10 or 12 years before all of the first- and second-order control stations are available, it seems to me that we should begin now to make, as far as conditions will permit, a more general use of the principles employed by the U.S. Coast and Geodetic Survey.

Our methods of surveying, including railway and highway location, based upon assumed data, and plotted by protractor or parallel ruler, are crude and rarely result in third-order accuracy. They should give way to a more general use of the coordinate system and to a higher degree of accuracy.

There are, however, obstacles in the path. The busy chief of party, running a 50-mile traverse for a railway location, power line, or highway, should not be told to start from a true meridian and check his instrument work on another meridian at the end of the survey, unless he is provided with a convenient formula for convergence, together with a table giving the distances intercepted on the parallels by 1 deg. of longitude, and the distances along the meridian between parallels. If there is bad alignment between two distant curves to be replaced by a tangent to the curves, he should not have to try to compute the two points of tangency, nor to plot the layout and find the points graphically,

as the problem can readily be solved by rectangular coordinates.

These comments are offered as a criticism of vicious practices current in ordinary field work, and as a plea to those who authorize our surveys to institute a more general adoption of the principles offered us by the U.S. Coast and Geodetic Survey. We do not have to wait until their first- and second-order net is completed to adopt the principles simplified for us by Captain Patton and his able associates.

GEORGE F. SYME, M. Am. Soc. C.E.
Senior Highway Engineer
State Highway Commission

Raleigh, N.C.
June 15, 1931

Existing Surveys Should Be Connected

EDITOR: In his interesting paper, in the June issue, Captain Patton has described the utility of control surveys in the several fields of engineering and has discussed in detail their usefulness in topographic surveying, city planning, and property defining. Pittsburgh is not the only city where it is necessary to use tapes of different lengths to reproduce original measurements. The potential value of both horizontal and vertical controls in topographic surveying and city planning, as well as in many other fields, needs no further demonstration, although their value in making boundary surveys is not quite so indisputable. The use of these surveys in fixing the western end of the northern international boundary has been mentioned by Captain Patton, and it seems to me important to connect this boundary with first-order triangulation. Next in importance comes the connection of the state boundaries, for, with the increase in the number of bridges and tunnels connecting states, the question of jurisdiction may arise. Therefore, the location of the actual division line should be proved through connection with control points.

The extensive construction of improved highways crossing the states in every direction has opened a new field for control surveys, and it is the practice in many states and counties to monument the side lines of such highways. These monuments should be connected with the U.S. Coast and Geodetic Survey's triangulation points so that the coordinates and elevation of every monument may be computed.

The Surveying and Mapping Division may well exert its influence with state highway officials to adopt this procedure. Such a network, when checked, compensated, and made available for general engineering practice, would be a tremendous factor in accelerating the use of both horizontal and vertical controls. Township lines and property boundaries along such highways would automatically become connected with the control system, thereby extending the advantages of control to individual property boundaries without entailing much expense to the property owner.

First-order triangulation control points in the more thickly populated eastern states should not be more than 5 miles, instead of 25 miles, apart and, near the cities, perhaps not more than one mile apart. Since cities are likely to need the control points first, the U.S. Coast and Geodetic Survey should take pains to establish points near city boundaries. For small cities in flat, or even rolling, country, it would be more generally useful if the control could take the form of a traverse on the boundaries with a maximum field error of 1:100,000; and if it could set monuments at the angle points (also intermediate points on long lines), connect with the triangulation, and establish a system of plane coordinates. With such an accurate horizontal control as a basis, the city could then establish intermediate traverses with a maximum error of 1:5,000 (0.01 ft. in a city block) and the necessary lines of levels.

A great deal may be said in favor of the practice of referring street lines to brick or stone buildings, for the obliteration of a building means the loss of only one of a number of points in a line which may be easily reestablished. However, street monuments, which should be set under the sidewalk and protected by a metal casing flush with it, are more definite and time-saving.

HENRY J. SHERMAN, M. Am. Soc. C.E.
Sherman and Sleeper, Consulting Engineers

Camden, N.J.
June 28, 1931

Some Design Features of Welded Beams

DEAR SIR: I have been much interested in Leonard C. Jordan's letter in the June issue, commenting on the design of welded buildings. It would seem, however, that many of these comments could well be applied to riveted work as well. It is true that the design of welded connections is still in the formative stage and, no doubt, types of joints have been used which will not bear careful analysis. However, it is our experience that a welded joint can be safely designed fully as economically as a riveted joint, and still be as flexible or as rigid as desired.

The remarks of Mr. Jordan concerning the deflection of beams, and the consequent angular rotation of end sections, are, of course, perfectly true. If, by welding or any other method of fastening, the beam is restrained at the end, the connection should be designed for this condition. Side clip angles to the web of the beam may be used for the end connection. Or, if a seat is used and attached to the beam by welding, a top clip angle welded along the toes to the top flange of the beam and to the column—or a side clip to the web, in the case of a beam framing into a girder—will give sufficient flexibility to allow the beam to take its deflection without unduly straining the welds, and at the same time provide the required lateral stiffness.

If it is necessary to design an end connection for full restraint, we have found no serious difficulties in providing a proper connection. Of course, if by a 100 per cent weld is meant welding around the entire outline of the beam, to the girder or column, such a method would offer considerable difficulty. It would entail considerable overhead welding, if done in the field, and a technic probably beyond that of the average operator. But with proper design, the connection can, except in the case of very peculiar conditions, be made fully as strong as the beam itself. At the same time overhead welding can be avoided, and the erection process remain quite simple.

We have recently been the designing engineers for a 14-story office building, which was shop-riveted and field-welded. This was not, however, designed as a riveted job with welds substituted for rivets in the field. It was

designed, as mentioned in Mr. Jordan's letter, with particular attention to welding in the field. The shop riveting was used for the purpose of allowing wider competition among the structural shops, few of which were equipped at the time to handle a shop-welded job economically.

It is very gratifying to have comments on this subject published, for it is only by such an interchange of ideas that structural practice can be adapted to welding, tending toward a degree of uniformity comparable with the present well standardized riveting practice.

Anthony S. Coombs, Assoc. M. Am. Soc. C.E.
Engineer, The Whitney Engineering Company

Boston, Mass.
June 8, 1931

Ohio's New Arbitration Law

Dear Sir: In connection with the articles on arbitration by Mr. Stevens and Mr. Beatty, appearing in Civil Engineering for June, it may be noted that Amended Senate Bill No. 41 (Sec. 12148–1 et seq., General Code of Ohio), passed by the present session of the general assembly, and effective July 28, 1931, places Ohio among those states having authoritative legislation on arbitration.

The recent enactment stipulates that: "A provision in any written contract, except as provided in subsections (1) and (2) of this section, to settle by arbitration a controversy thereafter arising out of such contract, or out of the refusal to perform the whole or any part thereof, or any agreement in writing between two or more persons to submit to arbitration any controversy existing between them at the time of the agreement to submit, shall be valid, irrevocable, and enforceable, save upon such grounds as exist at law or in equity for the revocation of any contract."

Exceptions are: (1) contracts between employers and employees in respect to conditions or terms of employment; (2) contracts entered into or awards made prior to the effective date of the act; and (3) controversies involving the title to, or the possession of, real estate, with certain exceptions.

In case suit is brought on any issue referable to arbitration under such an agreement, the court is required, on application, to stay the trial until such arbitration has been carried out. A party aggrieved by the failure or refusal of another to perform under a written agreement for arbitration may petition the court for an order directing such arbitration, and the court shall so act, if satisfied that the making of the agreement for arbitration or the failure to comply therewith is not in issue. The details of the arbitration and the power of the court to confirm or set aside the award are set forth at some length, vacation being only on the ground of fraud, partiality, misconduct, or similar cause, in which case the court may correct the award.

Arbitration under common law, by mutual agreement, can, of course, be carried out as heretofore. It may be noted that court decisions indicate that a unanimous award is required under such proceedings.

It is generally admitted that practically all public works contracts are fair to the contractor only in so far as the engineer is fair and reasonable. Every such contract should contain a proper arbitration clause, and the scope of such provision should be accurately defined. Having had some experience both as arbitrator and as a party in dispute, I have been impressed with the value and fairness of this proposition.

The arbitration clause in the standard specifications and contracts of the Franklin County (Ohio) Sanitary Engineering Department reads as follows:

"When necessary to submit to arbitration any question subject thereto under the terms of this contract, the arbitrators shall be three in number, one being a competent engineer, selected and paid by the board; one being an experienced construction man, selected and paid by the contractor; and one being a disinterested attorney, selected by the Judges of the Court of Common Pleas of Franklin County, and paid jointly by the parties hereto."

The matters referable to arbitration under these specifications are: (1) the amount of damages payable to the contractor if work is suspended by the board for causes for which the contractor is in no way responsible; (2) the price to be paid on account of alterations of the contract made by the board (State law requires that such price be agreed upon in writing before such work is done, and the specification and contract stipulate that, if arbitration is necessary, the parties shall accept the award and execute the required agreement in accordance therewith); (3) the addition to or deduction from contract price when work for a fixed price is increased or diminished; (4) the price to be paid for the use of heavy equipment on extra work paid for on a cost-plus-percentage basis.

The selection of the arbitration board in this manner does away with the possibility of the appointment of a partial third member through the influence of the stronger of the two named by the parties in dispute, which always exists under the customary method. It is natural that an arbitrator may lean slightly to the side of the party who retains or pays him, although the opposite is sometimes the case. The naming of a disinterested attorney by the court may often be tantamount to the selection of an umpire. The plan has operated very satisfactorily.

E. G. Bradbury, M. Am. Soc. C.E.
Sanitary Engineer
Franklin County, Ohio

Columbus, Ohio
June 13, 1931

Need for a Board of Arbitrators

Editor: As Mr. Stevens and Mr. Beatty pointed out, in their symposium in the June issue, the question of arbitration is in theory so desirable that it is hard to find anyone opposed to it, but the difficulty has always been in getting the right arbitrators. Although the human imagination likes to dwell on the thought of a just judge, it is very hard to find one. In his closing paragraph, Mr. Beatty refers to the work of the American Arbitration Association in getting people to consent to serve as arbitrators, which recalls to my mind a plan that I suggested some 25 years ago, in a discussion (Transactions, Vol. 56, page 137) of a paper by Albert J. Himes, then City Manager of Dayton.

My plan was that the American Society of Civil Engineers should elect for life, from among its older members, distinguished engineers to a Board of Arbitration, providing for a certain number of arbitrators from each District, and that, as vacancies occurred by death or resignation, new members should be elected.

At present, the greatest honor that the Society can confer upon an engineer is the presidency of our organization, but that does not fill the need for recognition of merit, as we have about 15,000 members, and can

only elect one a year as president. So my proposed Board of Arbitration, standing in the capacity of a sort of supreme court for our own affairs, would create additional honors for the Society to confer.

The parties wishing to refer a dispute to arbitration would write to the Secretary of the Society, giving an outline of the matter in dispute, the amount of money involved, and the number of arbitrators desired. In due time, a selection of arbitrators would be made through the machinery of the Society, and the time and place for the hearing fixed. With a reasonable scale of fees, such arbitration would be profitable to our profession as well as just and serviceable to the disputants.

AUGUSTUS SMITH, M. Am. Soc. C.E.
President, Bergen Point Iron Works

Roselle, N.J.
June 12, 1931

Engineers Not Responsible for Poor City Plans

EDITOR: The paper by Mr. Knowles on "The Civil Engineer's Part in the City Plan," in the March issue, is very interesting. The engineer assumes that he must maintain the same attitude toward his client as the architect or other professional man. If the client wishes embellishments, the engineer can provide them. If, on the other hand, he is interested in a utilitarian structure, the engineer will also provide that.

THIRD AVENUE BRIDGE, MINNEAPOLIS
Designed by Frederick William Cappelen, M. Am. Soc. C.E.

When the engineer conceived the idea of piping water under pressure to every building and then using this water as a vehicle to carry off waste matter by gravity, he made it possible for large aggregations of people to live together in a healthful way. Today there is no limit to the size of a city, provided people can get from place to place in an allotted time; so the engineer has designed a transportation system to solve this problem. Physical accomplishments are thus coordinated with social, economic, and sanitary needs.

A bridge thus facilitates the intermingling of people and the movement of commodities. The design and construction of a bridge is an architectural and engineering problem, and not one of city planning, although the location of the bridge falls within that province.

In Minneapolis there was a real need for a bridge on Third Avenue. Preliminary investigations revealed difficult foundation problems. After test borings, however, the city engineer laid out a bridge on a reverse curve which eliminated the foundation problems and still kept the bridge in line with the origin and destination of traffic. This successful attempt to coordinate social and economic needs with engineering requirements was recognized by citizens of the city, who, upon the death of the engineer, named his last structure the Cappelen Memorial Bridge.

The engineer is not responsible for the rectangular system of streets, poorly designed blocks, or inadequate street widths. Real estate men, owners, and city councils must bear this responsibility. Through the years, when a village became a city, and a city a metropolis in a short period of time, the real estate men contended, and probably rightly so, that the rectangular system was the only one which would permit of the changes incident to growth—the changing of residence districts to mercantile districts, and of mercantile districts to factory districts. In the future, such mutations are likely to occur only in districts and not in cities. This gives the city planner of today his opportunity.

GEORGE H. HERROLD, M. Am. Soc. C.E.
Managing Director and Engineer
The City Planning Board

St. Paul, Minn.
June 1, 1931

Coordination in Planning

DEAR SIR: The excellent paper by Mr. Knowles, in the March issue, leaves one with several very lasting thoughts. The first is one of keen appreciation that planning is a cooperative job of coordinating the experience and knowledge of many individuals. This has been particularly true of the Regional Plan of the Philadelphia Tri-State District, where over 200 representative engineers, architects, and landscape architects within the region are working together to make the plan for the 4,500 sq. miles. It is through the coordination of their detailed knowledge of these areas with the studies made by the staff and consultants that the regional plan is possible.

The second thought suggested by Mr. Knowles' paper is that if a thing is worth doing at all it is worth doing well. We are coming to want to live in a "Model *A*" instead of a "Model *T*" country. The emphasis on the importance of greater attention to the conservation of natural resources is certainly well taken. All of these resources have been exploited in the past. In the building and rebuilding of cities there should be a greater use of existing knowledge of the balance of nature, and a research into its unknown quantities.

In this age of enthusiasm, it is easy to overlook the comprehensive in close attention to the specific. Often this may lead to an unwarranted concentration of expense in a monumental attack on a local problem that might better be solved by inexpensive and comprehensive treatment of regional scope. If we take a frank look at our modern cities, we see tremendous opportunities for improvement. There are millions of unhappy, idle men, eager for something to do. The causes and cures are many. Perhaps the rebuilding of our country, according to comprehensive plans, and the more scientific operation of municipal finance may help in the future to solve the unemployment situation.

JOSEPH T. WOODRUFF,
Planning Engineer
Regional Planning Federation of the Philadelphia Tri-State District

Philadelphia, Pa.
June 3, 1931

SOCIETY AFFAIRS

Official and Semi-Official

Tacoma—An Outstanding Convention

Another Quarterly Meeting has come and gone. Tacoma has been host to an unusually large and successful convention, leaving only happy memories. The preliminaries started early, when a special tour left Chicago on July 1; and the break-up of the various parties was extended even beyond the normal time as various groups made special trips and visits at the close of the sessions proper. But whether considered strictly from the viewpoint of the meeting itself or from that of its larger aspects, the affair was entirely successful from start to finish.

Attendance is only one feature of any meeting, and is not always a true index of its value; but the fact that 525 or more members and guests gathered in Tacoma indicates at least a strong interest. After having assembled in such large numbers, the Meeting was particularly characterized by the congenial opportunities afforded both socially and professionally, and by the intimate touches added to all the functions by the local members and their families. It goes without question that a large number of the nearby members gave without stint of their time and effort. The many souvenirs and special features provided through the personal efforts of local members and their wives were but indicative of the undertone everywhere apparent.

As to weather, it was made to order, perfect in every respect and particularly appreciated on the occasion of Friday's splendid boat trip. On the social side, the Hotel Winthrop in Tacoma was practically given over to attending members—a big family party as it were. A similar feature characterized the trip from Chicago, on which special car and diner service was made available through the courtesy of the Great Northern Railway. These conveniences were provided all the way from Chicago to Glacier National Park and right through to Tacoma. All were roused at 4 a.m., the last day, to view the Cascades Tunnel. Various features were explained in detail by engineers of the railway who accompanied the party throughout the trip.

Speaking of the social features connected with the Meeting proper, the shore dinner was a great success, also the banquet and the luncheon with the Tacoma Engineers Club. The approximate attendance at the various events, starting with the gathering at Glacier National Park, was as follows:

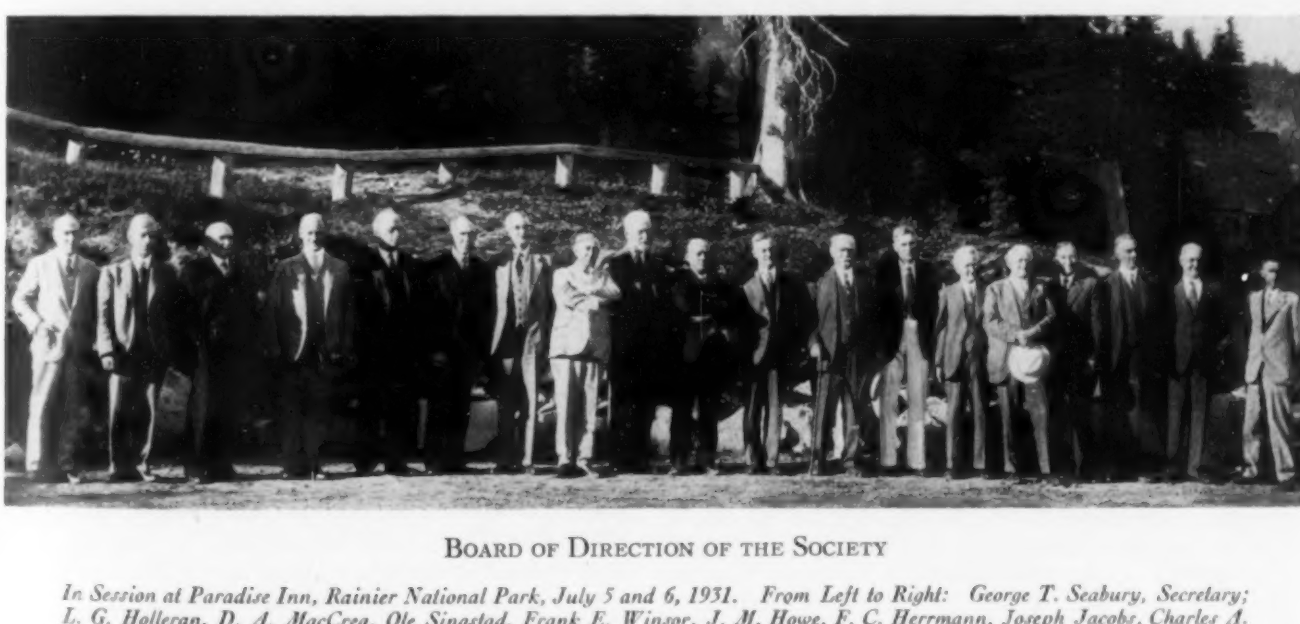
Visit to Glacier National Park	40
Visit to Paradise Inn, Rainier National Park	70
Total Registration—Tacoma	510
General Technical Session	300
Technical Division Sessions	
Irrigation	80
Structural	120
City Planning and Highway	45
Power and Construction	170
Social Events	
Wednesday dinner and entertainment	240
Ladies' drive	160
Shore dinner and dance	275
Friday boat trip	240
Saturday Trip, Cushman Power Project	205

Both Oregon and California contributed large delegations to assist Washington in rounding out a representative attendance from the Pacific Coast.

Each of the Technical Sessions, as well as the social gatherings, reflected great credit on the local committee in charge of arrangements. This committee was headed by Walter J. Ryan, Chairman, assisted by a hard-working and efficient group composed of E. F. Pugsley, of Seattle; Eugene Logan, of Spokane; F. R. Schanck, of Portland; R. K. Tiffany, of Olympia, President of the Tacoma Section; and C. E. Putnam, Vice-President of the Tacoma Section; W. A. Kunigk, W. C. Raleigh, G. L. Parker, and W. J. Roberts, all of Tacoma.

In the special entertainment of the large group of ladies who attended, great assistance was rendered through the efforts of the Ladies Auxiliary, of which Mrs. Glenn L. Parker is president.

Special reference to the technical features of the Tacoma sessions may well await the September issue. There will be found abstracts of the various papers presented, so that members who were not fortunate enough to be in attendance may profit by the contributions made and have the papers available at the first opportunity. The entire technical part of the September issue will be devoted to these brief digests of the many fascinating papers which helped to make the Tacoma Convention an outstanding technical, as well as social, success.



BOARD OF DIRECTION OF THE SOCIETY

In Session at Paradise Inn, Rainier National Park, July 5 and 6, 1931. From Left to Right: George T. Seabury, Secretary; L. G. Holleran, D. A. MacCrea, Ole Singstad, Frank E. Winsor, J. M. Howe, F. C. Herrmann, Joseph Jacobs, Charles A. Mead, Allan T. Dusenbury, Frank L. Nicholson, Francis Lee Stuart, President; Clyde T. Morris, E. K. Morse, J. N. Chester, Ralph Budd, Henry R. Buck, Roy C. Gowdy, and C. E. Beam, Assistant Secretary.

Secretary's Abstract of Board of Direction Meeting, Rainier National Park, July, 6, 7

On July 6 and 7, 1931, the Board of Direction held its regular quarterly meeting at Paradise Inn in Rainier National Park, Wash., with Francis Lee Stuart, President, in the chair; and present: George T. Seabury, Secretary; and Messrs. Buck, Budd, Chester, Dusenbury, Gowdy, Herrmann, Holleran, Howe, Jacobs, MacCrea, Mead, Morris, Morse, Nicholson, Singstad, and Winsor.

Approval of Minutes

The minutes of the Board Meeting held April 13, 14, 1931, were approved as written.

Appropriations

Of several applications for new or increased appropriations, the Board approved only two, one for the support of the Engineering Societies Employment Service and the other to permit the Committee on Registration to hold another meeting in order to further develop its work before the winter's legislative sessions.

Approval of Changes in Local Section Constitutions

Changes in the constitutions of the Alabama and the Philadelphia Local Sections were approved. Changes in the Texas Section Constitution providing for "Local Branches" were referred to the Committee on Local Sections for recommendation.

Juniors Admitted to Participation in Technical Division Activities

Upon the suggestion of the Technical Procedure Committee, the Board directed that the Technical Division constitutions be changed when necessary to permit Juniors to participate in the election of the officers of the Division Executive Committees and to vote in other matters referring to Division administration.

American Standards Association Revised Constitution

As one of the member bodies of the American Standards Association, the Board gave its formal ratification of that organization's proposed constitutional revisions.

Death of George F. Swain, Past-President and Honorary Member

Upon receipt of notice of the death of Past-President and Honorary Member, George F. Swain, the Board expressed its deep regret and directed that a communication be forwarded to Mrs. Swain and that a committee be appointed to draft a suitable resolution to be incorporated in the Board's minutes.

John Fritz Medal Board of Award

The term of John F. Stevens as one of the Society's four representatives on the John Fritz Medal Board of Award will terminate in October 1931. Francis Lee Stuart was appointed to fill the vacancy.

Columbia Scholarship

Upon recommendation of the Columbia University Scholarship Committee, the newly reorganized scholarship at Columbia University was awarded to David C. MacMurray, Jun. Am. Soc. C.E., of West Milford, N.J.

Freeman Traveling Scholarship

Upon recommendation of the Freeman Traveling Scholarship Committee, Hans Kramer, Assoc. M. Am. Soc. C.E., was reappointed as the 1931–1932 Freeman Traveling Scholar.

Tests on Reinforced Concrete Columns

The Board voted to endorse to Engineering Foundation the researches being carried on at the University of Illinois and Lehigh University on reinforced concrete columns.

Society Prizes

The report of the Society's Committee on Prizes was received. Final action will be take in October.

Committee on Publications

Report was received from the Society's Committee on Publications relative to a suggestion that some of the Society's publications might be issued only upon the payment of an additional charge. It was decided that the present practice of making all Society publications free to members should be continued. The Board also sustained the Committee on Publication's decision relative to the printing of certain material proposed for a forthcoming Manual on Piles and Pile Driving.

Committee on Professional Conduct

The Board considered five cases of alleged unprofessional conduct.

Student Chapter at Pennsylvania Military College

Upon recommendation of the Society's Committee on Student Chapters, the Board approved of the application for a Student Chapter at the Pennsylvania Military College. Also, upon recommendation of the Committee on Student Chapters, the Board voted to extend to the members of the graduating class of Newark College of Engineering who had been members of the newly formed Student Chapter at that institution, the remission of the equivalent of one year's dues, upon their admission as Junior members of the Society.

Registration of Engineers

With reference to the Joint Committee of Architects and Engineers, the Board adopted the following resolution:

WHEREAS the Joint Committee on Registration of Architects and Engineers has completed its duties; and

WHEREAS the Board of Direction of the American Society of Civil Engineers realizes the great amount of work and time involved in the negotiations and studies in connection with the preparation of its report; and

WHEREAS the Board considers that the work of this committee had a marked effect in clarifying the situation with regard to the proposed legislation affecting the interest of engineers;

Now, therefore, be it resolved that the Board, in terminating the services of the committee, hereby expresses its hearty appreciation and thanks to the engineer members of the committee for the services rendered.

* * * *

In response to a request submitted by American Engineering Council to all its member-organizations that it be advised as to the official attitude of each, the Board voted that it approves of registration of engineers.

* * * *

Based on a report submitted by the Society's Committee on Registration of Engineers, the Board adopted six principles to which it subscribes with respect to the registration of engineers. Briefly, these principles are to the effect that there should be no division of the engineering profession into its several branches in matters of registration, although there is also recognized the advisability, under necessity, of making such concessions as will provide for the registration of certain engineers as professional engineers with special qualifications. [An item appearing elsewhere in this department gives these principles in detail.]

Topographic Mapping of the United States

The Board gave hearty endorsement to the efforts which are to be made to secure from the Federal Government sufficient appropriations to carry out the intent of the Temple Act, Public Law No. 498, 68th Congress, February 27, 1925, and to the removal of restrictive clauses in the appropriation bills which hinder or defeat the intent of the original Temple Act. A small committee, possibly with subcommittees in every state, was authorized to cooperate in this program.

State Engineering Councils

Responding to a request of the American Institute of Electrical Engineers, the Board authorized the appointment of three members to join with similar representatives of the Mining, Mechanical, and Electrical Engineers and American Engineering Council to study and report upon the desirability and practicability of forming state engineering councils in each state for the purpose of representing the engineering profession in legislation and other nontechnical matters affecting the status of the profession and the welfare of the public.

Technological Employment

Responding to a request from the Department of Labor, the Board authorized the appointment of a committee of three Society members to assist in the study which is to be made by that department of the matter of technological employment.

Sanitary Engineering in State Boards of Health

Being advised that a radical change is proposed by the State Board of Health of North Carolina with respect to the Bureau of Engineering and Inspection, the Board authorized that there be forwarded to that body and to the Governor of the State a vigorous protest against any change which would be likely to result in the impairment of the sanitary engineering work which has been carried on in that state.

Adjournment

The Board adjourned to meet at 10 a.m., Monday, October 5, at St. Paul, Minn.

Fall Meeting—St. Paul

After a period of 12 years, the Society returns to the upper Mississippi Valley to hold its gathering, the Fall Meeting being scheduled for St. Paul, October 7–10, 1931. Remembrances of the Convention in Milwaukee only two years ago will induce many members to return to the neighboring state of Minnesota and enjoy a few days of pleasant associations.

Regional problems, as usual, will take up much of the time at the Technical Sessions. In particular, mining and mining interests will occupy considerable attention. Leaders in the industry have been interested in this meeting, so that a worthwhile program is in store. The importance of transportation problems in the upper Mississippi Valley will also demand a large hearing and will be adequately treated by responsible experts.

Nor will the Technical Divisions be lacking in suitable arrangements for ample discussion. Six Divisions have already expressed a desire to cooperate with individual sessions, thus guaranteeing a well rounded program.

Not to be outdone on the social side, the committees are preparing a notable series of entertainments so that no hour will be left without its suitable attraction for the visitor. Outstanding among these latter plans is the prospect of a more extended visit than usual to one of the important mining centers.

As further details are matured, members will be informed in later issues.

Registration and Solidarity

At the meeting of the Board of Direction on July 6, a resolution was passed with regard to the desirability of solidarity in the civil engineering profession, as applicable to registration laws. The resolution follows:

Whereas the several branches of the engineering profession have been referred to in some engineer registration laws as if there were sharp lines of division between them, and thus they were subject to exact definition as separate professions, and

Whereas, instead of sharp divisions, there is and must be always a great degree of overlapping of the several branches of the profession,

Be it resolved, therefore, that the following constitutes the principles to which the American Society of Civil Engineers subscribes with respect to this phase of the registration of engineers:

1. That division of the profession into its main branches, such as civil, mechanical, electrical, mining, and chemical engineering, would logically and ultimately tend to further partition into numerous subdivisions or specialties.

2. That subdivision or classification of the profession would inevitably result in groups of specialists seeking recognition by legislative authority of the special qualifications required in their practice, with the result that special laws would be secured for the restriction of the right to practice in that particular classification of engineering.

If classification of engineers were to be generally adopted, the profession of engineering would tend to degenerate into trade unionism, and jurisdictional disputes would ensue.

3. That registration laws should recognize the fact that all engineering practice is the application of common basic knowledge of the arts and sciences to the solution of engineering problems, and no speciality of engineering practice is of itself a profession.

This principle, when coupled in registration laws with a high standard of qualifications, will protect to the utmost both the public and the engineer.

4. That one of the most valuable services of the profession to the public is that of administering undertakings and projects which inherently comprehend a large number of the branches and subdivisions of engineering.

If the various subdivisions and branches were to be separately recognized and removed from the general practice of the profession, in time there would no longer be an engineering profession but, instead, a large group of specialists, no one of whom could be competent to manage, direct, and conceive engineering projects in their entirety.

5. That subclassification of the profession is contrary to the accepted principles of other professions, notably that of medicine, law, and architecture.

As an illustration, no legal subclassification is found of the practice of architecture into, say, structural, ecclesiastical, hotel, school, etc.

6. That while holding firmly to the foregoing principles, there is recognized the necessity, when existing laws restrict members of the profession from practice, of making such concessions as may be necessary to enable those members to practice by providing for their registration as professional engineers with special qualifications.

Civil Engineering News of the Federal Government

As Reported by American Engineering Council

Bureau of Agricultural Engineering

The Bureau of Agricultural Engineering, authorized by act of the last Congress, came into existence on July 1. This bureau takes the place of the Division of Agricultural Engineering, which was formerly a portion of the Bureau of Public Roads.

According to announcement from Arthur M. Hyde, Secretary of Agriculture, S. H. McCrory, M. Am. Soc. C.E., is to head the new bureau. Mr. McCrory was formerly Chief of the Division of Agricultural Engineering and has been in the service of the Department of Agriculture for 24 years. He is a former president of the American Society of Agricultural Engineers.

In announcing the appointment, Secretary Hyde said:

"The importance of sound engineering practice as a factor in modern agriculture has made the creation of a new bureau necessary. Agricultural engineering is one of the younger professions and its importance is steadily increasing. The engineering work of the department has dealt with irrigation, drainage, soil-erosion control, farm mechanical equipment, and farm structures. The high efficiency of American agriculture has been in a great measure the result of the rapid development of farm machinery, and agricultural engineering has been instrumental in this development.

"The new bureau will carry on the current activities of the old division. The department announces it will continue to emphasize farm mechanical equipment studies. These activities will center for the present on such work as developing machinery to combat crop pests such as the European corn borer, investigations designed to improve machinery for distributing fertilizer, and experimental studies of cotton ginning. The engineering studies dealing with the control of soil erosion will be pushed forward as rapidly as possible. Eight experimental farms for the study of this problem are now in operation. In this work the Bureau of Chemistry and Soils and the Forest Service are cooperating."

Director of Federal Employment Stabilization Board Named

The organization of the new Federal Employment Stabilization Board, authorized by the last Congress, is now under way. D. H. Sawyer, M. Am. Soc. C.E., Consulting Engineer of New York, was recently appointed director of this board by Robert P. Lamont, Secretary of Commerce. Mr. Lamont is chairman of the board, whose other members are the Secretaries of the Treasury, Agriculture, and Labor.

One of the main functions of the board is to supply the President with accurate information at all times respecting trends in construction under private direction as well as that under state and municipal control. Compilation of statistics on construction of all

kinds is included in the preliminary conception of the board's work, and from these data the board will be able to form an opinion concerning the most effective time for launching auxiliary federal construction programs.

It is hoped that from the information supplied through this new Employment Stabilization Board, the Federal Government may accomplish much in leveling the peaks of the economic cycle. Preliminary work along these lines has been done by the Division of Building and Housing. This division will now be transferred to jurisdiction of the new board.

Subcommittee on Relief from Unemployment Holds Meeting

The subcommittee appointed by Chairman R. F. Schuchardt of the Public Affairs Committee of American Engineering Council, on Relief from Unemployment, held a meeting in Pittsburgh on June 18. The subcommittee is composed of F. J. Chesterman, E. K. Ruth, M. Am. Soc. C.E.; W. R. Webster, R. C. Marshall, Jr., M. Am. Soc. C.E.; and L. W. Wallace, Executive Secretary of American Engineering Council. The committee devoted the entire day to deliberations and formulated a report which contemplates action along several lines.

Prof. George F. Swain

A commanding figure in the realm of engineering is lost to the ranks of the profession in the passing of George F. Swain, Hon. M. Am. Soc. C.E. His death occurred at his summer home in Holderness, N.H., on July 1, 1931. The funeral service held on July 3 at the Second Unitarian Church in Boston was largely attended by associates, friends, and former students.

His active nature carried him into many fields such as transportation, structures, and hydraulics. And yet throughout his entire life he remained true to his primary calling—he was one of the great engineering teachers. To every problem to which he bent his efforts, he bestowed a keen analytical interest. Hosts of young men went out into engineering life fired with his zeal. Many others were inspired by his numerous writings.

In late years he had been entirely confined as an invalid; but to his Boston home came a continual stream of engineering friends whom he delighted to welcome. Of all the tributes to a full and successful life, he cherished most the coveted distinction of Honorary Membership in the Society.


To The Verein Deutscher Ingenieure

On The Celebration of Its

SEVENTY-FIFTH ANNIVERSARY

June 1931

GREETINGS

Mindful of its Success in Uniting the Technical Men of Germany in one Organization, and thus Achieving Co-operation between the Various Branches of Engineering; Its Zeal in Initiating and Carrying Out Projects of Research; Its Activity in the Field of Publishing; in Technical Education, and in the Guidance of Proper Legislation;

The American Society of Civil Engineers offers Its Felicitations upon this Happy Occasion, with Heartiest Wishes for the Continuation of these Beneficent Activities, for the Maintenance of High Ideals, and for the Perpetuation of Cordial Relations between the Societies.

Francis Lee Stuart
President

George T. Seabury
Secretary

AMERICAN SOCIETY OF CIVIL ENGINEERS FOUNDED 1852

REPRODUCTION OF THE CERTIFICATE, ILLUMINATED IN COLOR, PRESENTED BY THE SOCIETY TO THE VEREIN DEUTSCHER INGENIEURE

Additions to Concrete Specifications

Notable progress was made in the consideration of specifications for concrete quality, design of mixes, and testing of reinforcement at the meeting of the Joint Committee on Standard Specification for Concrete and Reinforced Concrete, held at the Stevens Hotel, Chicago, on June 22 and 23. The Society is interested in this Committee on which it maintains the following official representation: W. A. Slater, Chairman; F. E. Richart and W. S. Thomson, Members Am. Soc. C.E.; and M. N. Clair and A. E. Lindau, Associate Members Am. Soc. C.E.

Concerning the quality of concrete, the dual requirement of a minimum strength and maximum water-cement ratio is proposed. The purpose of the limitation of the water-cement ratio is to avoid the use of unduly lean mixes and thus to safeguard the durability of concrete. A change from the 28-day to 7-day strength requirement is also being considered.

Recent developments in the field of ready-mixed concrete have raised new problems not covered by the former specifications. The committee proposes to incorporate suitable provisions for the control of ready-mixed concrete. On the subject of concrete reinforcement, the committee has gone on record as opposed to the provisions of permitting the machining of test specimens for determining the physical properties of deformed bars. The complete organization and previous progress of this committee were mentioned on page 753 of the May issue.

Appointments of Society Representatives

EARL STIMSON, M. Am. Soc. C.E., Chief Engineer, Maintenance, of the Boston and Ohio Railroad Company, has been appointed the Society's representative on the Sectional Committee on Specifications for Railroad Ties, under the Auspices of the American Standards Association.

Membership Applications

During one week of June, from the 16th to the 23d, applications for admission to the Society were received to the number of 81. For the current year, this appears to be the peak of the spring activity.

In explanation, it may be recalled that this large number corresponds with the graduating season in many engineering colleges. The number is largely made up of such young men, although it also includes a generous number of normal applications from older engineers.

This yearly influx of ambitious young men shows an interest in the Society which is indeed encouraging. In large measure, it reflects the prestige which has been conferred upon the organization through its many years of existence by the faithful labors of a large and enthusiastic membership.

Further Student Prize Winners

To the list published in the July issue, of members of Student Chapters to whom Local Sections had awarded prizes, additions are being continually received. This further list includes the following names:

Student	College	Local Section Giving Award
Edwin Rose	University of Cincinnati	Cincinnati Section
Otis Harold Walker	Kansas State College of Agriculture and Applied Science	Kansas State
Herbert E. Prater	University of Kansas	Kansas State
Jerome Claudius Baehr	Tulane	Louisiana
Clayton Reeves Lowe	Louisiana State	Louisiana
Frank E. Dolson	Washington University	St. Louis
Clarence Mortimer Hawkins	University of Virginia	Virginia
John Alexander Veech	Washington and Lee University	Virginia
Adolph M. Harris	Virginia Polytechnic Institute	Virginia

Our Library

Except for a few hundred books of very frequent usage and great demand, which are maintained in the Reading Room, the Society has no independent library. Its large collection of books was merged with the Engineering Societies Library when it moved to its present Headquarters.

As a result of the union of all the Founder Societies' Libraries in this one great assembly, Engineering Societies' Library exists as one of the valuable technical storehouses for books in existence, if not the most important in the entire world. What this Library is accomplishing is vividly seen in some of its records, as recently reported by its director, Harrison W. Craver.

On June 1 the main collection comprised 141,546 books and pamphlets. During the first five months of 1931, 4,880 books and pamphlets were either purchased or received as gifts. Of these, 3,030 were added to the main collection, which now represents 66,527 titles, indexed in the catalog under 37,100 subjects for ease in finding. The catalog contains 434,326 cards under 135,574 classifications. The budget for 1931 is $56,653.55.

The number of visitors to the Library during the five-month period was 12,255. Service was given to 18,726 members of the engineering profession. The wants of 2,553 members were supplied by telephone. Forty-two searches were made and 89 technical articles were translated. Orders for 21,691 photoprints were received from 2,136 persons. Information was sent to 1,561 members by letter, and books were loaned to 90 distant members at their request.

During the calendar year 1930, the Library was used by over 40,000 engineers. This year, despite the depression, an even larger number will be served.

Memoirs Available

Although Memoirs no longer appear currently each month in Proceedings, this does not mean that work on this important phase of Society activity has ceased. The fact of the matter is that Memoirs are continually being submitted by interested members and friends and are being put in type. Subsequently, in forthcoming issues of Transactions, they will appear as a permanent record of important engineering activities on the part of deceased members.

In the meantime, preprints of many of these Memoirs have been obtained and distributed to the authors and to the families of the deceased. Although it is not generally known, such copies of Memoirs are also available to any interested friends and may be had for the asking. For the convenience of members, the list of those now available is here included, as follows:

William Henry Adey
Andrews Allen
Kenneth Allen
Justin Kenderdine Anderson
Louis Russell Ash
Stedman Bent
Axel Samuel Frederick Berquist
Alexander Leslie Black
John Carlisle Bland
Stoerk Johan Bratager
Robert Brown
Morton Burden
Henry Amsden Burr
Maxwell Cunningham Byers
William Cain
George Linden Campen
William Waller Carson
Willis Chipman
Maurice Wurtz Cooley
Frank Eugene Davidson
George Davidson
Joseph Phineas Davis
Harry Espenship Detwiler
Raymond Arden Edwards
Lloyd Tilighman Emory
Harrison Robert Fehr, Sr.
Roger Morse Freeman
William James Fulton
Horace Delphos Gates
Thomas Golding Gerdine
Arthur Bates Goodwin
Mortimer Grant
Benjamin Mortimer Hall
James Hendricks Hallett
Charles Ellett Hart
Alfred Ernest Harvey
Harry Hawgood
Allen Hazen
Robert Grier Hemphill
Lewis Stirling Hereford
Clemens Herschel
Edward Baxter Hill
Edwin Allston Hill
John Wilmuth Hill
Albert Harrison Hogeland
William Hausner Hoyt
Marion Columbus Huckaby
Hector James Hughes
Andrew Murray Hunt
Thomas Pearson Kinsley
Sentaro Kondo
King Yang Kwong
George Herbert Leland
Eugene McLean Long
Henry Howell Lotter
Jacob Lott Ludlow
John Lundie
Henry Martyn MacKay
William Walter Maclay
Clark Rogers Mandigo
Marsden Manson
Charles Cyril Martin
George Arnold McCarthy
John Alexander McDonald
Anson Burlingame McGrew
Joseph Davis Metcalfe
Sheldon Elton Minor
Henry Mitchell
John Mitchell Moncrieff
Richard Montfort
Andreas Wendelbo Münster
George H. Norman
Cornelius Joseph O'Connor
Robert McKnight Pardee
Charles Wellman Parks
James Suydam Polhemus
James Bond Pope
George Frederick Porter
William Abbott Pratt
John William Raitt
William Couts Randolph, Jr.
William Boardman Reed
Claude Irvin Rhodes
Franklin Riffle
Edward Austin Rix
Thomas Rodd
Hans Henrik Rode
Joseph Warren Rogers
Marshall Pugh Rogers
John Henry Rostock
Harry Harwood Rousseau
Richard Lord Russell
George Fredrick Samuel
Nicholas Alexander Scripko
William Laurie Seaman
Ivan Oscar Shaffer
Robert Ames Shailer
Stanley Rush Sharts
Erastus Roland Simpson
Bronson Hasbrouck Smith
Jay L. Stannard
Harold David Stoll
Franklin Stevens Storey
John Gerard Theban
Walter Checkley Tiffany
Louis Lincoln Tribus
Edmund Kimball Turner
Charles Augustus Van Keuren
Robert Lawrence Van Sant
Harry Lee Van Zile
James Russell Vaughan
Edward Franklin Vincent
Fred J. Wagner
Albert Lowry Webster
George Smedley Webster
William Franklin Whitaker
James Edward Whitfield
Frank Clinton Wight
Charles Edward Willacker
William Fish Williams
Carlton Carpenter Witt
Adolph Yappen
Robert Elgene Yolton
Samuel McCain Young

A Preview of Proceedings

An outstanding characteristic of the August number of PROCEEDINGS each year has been the large amount of space allotted to discussion. The forthcoming issue is no exception to this rule. A number of papers that have been actively discussed during the past year or more are being closed by their authors in this issue. Prominent among such closing discussions will be that of Benjamin F. Groat, M. Am. Soc. C.E., whose paper, "The Theory of Similarity and Models," appeared in PROCEEDINGS for October 1930. In it he enunciated a concise theory of similarity in models, and showed that the materials used, including fluids, should be chosen, made, or arranged so as to adapt them especially for service in models. He has scouted the idea that there are different kinds of similarity. All the various designated laws of similarity should reduce immediately to Newton's one unique definition of the theorum.

GROAT CLAIMS BASIC ERROR IN MAXWELL'S VISCOSITY FORMULA

That the paper has been closely read is attested in various ways, especially by the discussion appearing in successive issues of PROCEEDINGS. Those who are interested in this subject will find in the August number that Mr. Groat refutes all of the critical arguments advanced against the acceptance of his basic principles and contributes numerous additions to present-day knowledge in the field of model engineering. According to Mr. Groat, the designer should need no correction factors for his experiments on a model other than the conversion ratios, which may all be derived immediately from certain fundamental ratios introduced in the main paper. Even these, he says, will be unnecessary if the experimenter uses model "weight, measures, and watches," in making his observations. Then the model is a theoretically perfect representation of the prototype and needs no correction.

Questions raised in discussions led Mr. Groat into what may prove to be a startling discovery, that in 1859 Maxwell made an error in the use of momentum in the original deduction of his formula, $\mu = {}^1/_3\, \rho\, c\, l$, for connecting the coefficient of viscosity of a gas with the density, molecular mean velocity, and molecular mean free path for the same gas and its molecules. In order to effect the necessary correction, Mr. Groat declares that all the values of the mean free path that have been calculated since 1859 by means of Maxwell's formula from experimental observations of the coefficient of viscosity must be doubled. According to the author, this error has arisen through a consistent misuse of the concept of momentum and momentum transfer.

In his conclusions, Mr. Groat states that the error disclosed and the corrections indicated in his closing discussion will involve changes in textbooks, handbooks, and all chemical and physical tables.

FINANCING STREET AND HIGHWAY IMPROVEMENTS

During the course of an entire year the Highway Division of the Society considered the subject of the "Equitable Distribution for Highway Purposes of Motor Vehicle Licenses and Gasoline Taxes" at three different meetings throughout the United States. Papers were presented successively by George B. Sowers, O. E. Carr, George H. Henderson, and Frederic E. Everett, Members Am. Soc. C.E. These papers and the oral discussion on them constitute the source of the present paper by R. W. Crum, M. Am. Soc. C.E., member of the Executive Committee of the Division and Director of the Highway Research Board, National Research Council, Washington, D.C.

Seldom is it possible to present a paper based on such well seasoned information as this, and it is the hope of the Highway Division that the membership at large will discuss this paper freely. Because of its timeliness it was first published in CIVIL ENGINEERING in March 1931. The paper has now been revised, rearranged, and corrected for its final form as a contribution to the PROCEEDINGS and TRANSACTIONS of the Society.

BIBLIOGRAPHY OF PHYSICAL PROPERTIES AND BEARING VALUE OF SOILS

In the August 1917 issue of PROCEEDINGS, the Society published its first bibliography on soils as Appendix D to a progress report by its special committee to codify present practice on the bearing value of soils for foundations. That list contained approximately 850 references. Other lists were similarly printed at later dates. The forthcoming supplement to that bibliography, in the August 1931 PROCEEDINGS, contains 800 additional references. The Society is indebted to the Carnegie Library of Pittsburgh for the compilation of this work.

The new bibliography contains references of publications that have appeared in the 11 years preceding the middle of 1928. References on erosion, sedimentation, and silting, which were included in the earlier bibliography, do not appear in the present list.

News of Local Sections

CENTRAL ILLINOIS SECTION

There were 56 members and guests in attendance at a dinner meeting of the Section, held in Champaign on May 25. The guests of the occasion and principal speakers were President Stuart and Secretary Seabury. The place of the engineer in the economic development of the country was the subject of President Stuart's talk, while Mr. Seabury outlined the activities of the Society during the past year.

CENTRAL OHIO SECTION

The regular monthly meeting of the Section was called to order by President Lee on June 18, with 36 members and guests present. The secretary announced that the student prize annually awarded by the Section to the student at Ohio State University having the highest point average in civil engineering has been won by John R. Morris, of Highland, Ohio. Under the supervision of Orris Bonney, the members enjoyed an inspection trip to the new Scioto-Olentangy intercepting sewer now under construction.

A luncheon meeting of the Central Ohio Section was held in Columbus on May 14, at which 33 members and guests were present. Clyde T. Morris, Professor of Structural Engineering at Ohio State University, read a very interesting paper on "Wind Stresses in Tall Buildings," which was thoroughly enjoyed by all present.

CLEVELAND SECTION

A luncheon meeting of the Section was held June 2, with 26 members and guests attending. After the business session, those present enjoyed an illustrated talk by Paul Gross on the subject of the hydro-electric developments of the Aluminum Company of America along the Saguenay River in Canada.

On May 7, the Cleveland Section held a luncheon meeting which was very well attended. A report was submitted by R. F. MacDowell, Civil and Sanitary Engineer, on the consideration of the question of segregating the Water Resources Branch of the U.S. Geological Survey as an independent bureau. "Improving the Cuyahoga River" was the subject of a discussion by Robert Hoffmann, Construction Engineer, Public Works, City of Cleveland.

DAYTON SECTION

After a luncheon on May 11 at the Engineers' Club, 25 members of the Dayton Section were taken on an inspection tour through Miller's Ford plant of the Dayton Power and Light Company. Another inspection trip was taken on June 8 to the city's new sewage disposal plant. This tour was conducted by W. W. Morehouse, Director of Water, and M. W. Tatlock, Superintendent of the Sewage Disposal Plant.

ILLINOIS SECTION

The award of certificates to engineering graduates of various Illinois colleges was a feature of the meeting of the Section, held in the Chicago Engineers' Club on May 29. In a brief talk, President Hansen reminded the student guests of their opportunity to study the causes of the present depression and to seek remedies for it. Among the speakers were Dr. Hatt, of Purdue University; Professors Maney and Hathaway, of Northwestern University; Professor Huntington, of the University of Illinois; Professor

Bennett, of Lewis Institute; and Professor Wells, of Armour Institute of Technology. There were 40 members and guests in attendance.

Los Angeles Section

A luncheon in honor of President Stuart was given by Mr. Linton, president of the Los Angeles Section, at the Pacific Coast Club, on July 17. After luncheon, which was attended by various prominent local engineers and officials, the group were taken on a tour of the harbor by George F. Nicholson, Chief Engineer of the Los Angeles Harbor. Having served as Consulting Engineer for the Greater Harbor Committee of 200, President Stuart was particularly interested in this feature of his visit.

In the evening, a meeting of the Los Angeles Section was held at the Elks' Club, with about 65 members and guests in attendance. A program consisting of music, vocal solos, and dancing had been arranged, and an interesting account of the Tacoma Meeting was given by Mr. Linton. The principal event of the evening was President Stuart's address on the present economic condition of the country, as it affects the profession of civil engineering.

Louisiana Section

More than 40 members of the Louisiana Section, as guests of the New Orleans Levee Board, made an inspection trip on May 2 to the lake-front development project being constructed on Lake

Group of Members of the Louisiana Section

Pontchartrain. Traveling by boat, work train, and on foot, the members examined the entire length of the sea wall, which they consider the ultimate solution to the reclamation and stabilization of the lake front. The party of guest engineers was headed by Colonel Bres, chairman of the Aims and Activities Committee of the Louisiana Section of the Society, while the levee board was headed by A. L. Shushan.

Miami Section

A meeting of the Miami Section was held at the Coral Gables Golf and Country Club on April 20, with 18 members in attendance. The principal speaker was F. J. Nebiker, of Everglades, Fla., who gave an instructive talk on Everglades drainage and development work in Collier County.

The business program of the meeting of the Section, held in Miami on May 28, included the election of M. R. Kays, of West Palm Beach, to the position of president of the Section, recently left vacant by the resignation of George P. Morrill, who is transferring his business location away from Florida. Following an illustrated lecture on the Catskill water supply of the City of New York, there was a general discussion on the subject of water supply.

Milwaukee Section

At the meeting on May 20 of the Milwaukee Section, a report by Mr. Lundahl, Chairman of the National Affairs Committee, was discussed. A motion was made, seconded, and carried that this committee be directed to take on the duties of a committee on "Functional Expansion." The meeting was held just prior to the regular meeting of the Engineers' Society of Milwaukee, which was under the auspices of the Milwaukee Section of the Society, and at which Emil Fritch gave an illustrated address on Japanese methods of making rail and tie renewals on Japanese-operated railroads.

Nebraska Section

On his way to the Summer Meeting at Tacoma, President Stuart was the guest of honor at a meeting of the Nebraska Section, held on June 29, in Omaha. He spoke on the subject of the obligation of the engineer to his community. Officers for the coming year were elected as follows: T. A. Leisen, President; Glenn Mason, Vice-President; and Rex Edgecomb, Secretary.

Philadelphia Section

There were 80 in attendance at the annual meeting of the Section, held on June 1, with President Stuart and Secretary Seabury as guests. The early days of the Philadelphia Section and the history of its growth were the subject of a talk given by Charles H. Stevens, Director of the Society. Following this, President Stuart gave an address emphasizing the need and opportunity for engineers to aid in the present economic crisis. At the conclusion of President Stuart's address, Secretary Seabury talked on Society activities, touching in particular upon the subject of registration of engineers. The officers of the Philadelphia Section for the coming year are as follows: James W. Follin, President; Sanford W. Sawin, Vice-President; and Charles A. Howland, Secretary-Treasurer.

Portland Section

Members of the Oregon State Agricultural College Student Chapter were guests of the Portland Section at a meeting held at the University Club on May 27. The feature of the occasion was the presentation of the three prize-winning papers in the recent contest conducted by the Portland Section for Junior membership in the Society. The Student Chapter members who won these membership prizes are Dale Sturmer, F. W. Parker, and Euel F. Philpott.

Sacramento Section

The Sacramento Section continues its practice of holding weekly meetings, all of which are very well attended. Among the well known speakers whom the engineers have enjoyed hearing are Col. B. C. Allin, Manager of the Port of Stockton; R. D. Goodrich, Senior Hydraulic Engineer with the Sacramento Office of the U.S. Engineering Department; J. Burdette Brown, extension specialist in irrigation with the University of California; and T. L. Phillips, Principal Assistant Engineer of the Western Pacific Railroad.

Seattle Section

Business routine occupied the greater part of the monthly meeting of the Seattle Section, held at the Engineers' Club, June 22, with 108 in attendance. The speaker of the evening was Admiral L. E. Gregory, C.E.C., U.S.N., Retired. The World's Fair, to be held in Chicago in 1933, was the subject on which Admiral Gregory spoke. He was former Director of World's Fair Exhibits.

St. Louis Section

The regular monthly luncheon of the St. Louis Section was held at the Hotel Mayfair on June 22. An interesting illustrated talk on "Our Mineral Resources" was given by W. M. Weigel, Mineral Technologist of the Missouri Pacific Railroad.

Student Chapter News

University of Colorado Student Chapter

Two meetings a month, with an average attendance of 53 members for each meeting, established a record for the University of Colorado Student Chapter during the past year. Although the programs for these meetings usually consisted of papers given by members of the senior classes in civil and architectural engineering, several men prominent in the profession and in the Society were also engaged as speakers.

The following officers have been elected for the coming year: Frank Goehring, President; Donald Sutherland, Vice-President; Charles Neel, Secretary; and Paul Warren, Treasurer.

ITEMS OF INTEREST

Engineering Events in Brief

Generous Gift to the Engineering Foundation

THE ANNOUNCEMENT comes from John V. N. Dorr, President of the United Engineering Trustees, Inc., and H. Hobart Porter, M. Am. Soc. C.E., Chairman of the Engineering Foundation, that Ambrose Swasey, Hon. M. Am. Soc. C.E., founder of the Engineering Foundation, has just added another $250,000 to his previous gifts, bringing their total to $750,000.

Born at Exeter, N.H., nearly 85 years ago, Mr. Swasey is the surviving member of the firm of Warner and Swasey, of Cleveland, Ohio, famous for the building of great telescopes, and of instruments and machine tools of precision. The Engineering Foundation was founded in 1914 on the basis of his conception of a research service that would be of broad benefit to the profession of engineering and to mankind. It was established by the national societies of Civil, Mining and Metallurgical, Mechanical, and Electrical Engineers.

This latest gift was made at a dinner at the University Club, given by Chairman Porter of the Foundation, at which Mr. Swasey was the guest of honor. There were present also more than 30 presidents and former presidents of national engineering societies, of the United Engineering Trustees, and of the Engineering Foundation, as well as other nationally prominent engineers.

Flood Control in Hungary

CONSIDERABLE interest attaches to the measures adopted for flood control which have recently been observed in Hungary by Hans Kramer, Assoc. M. Am. Soc. C.E., Freeman Fund Scholar. The following is an extract from one of Lieutenant Kramer's recent reports.

"On the Tisza, which drains the great Hungarian plain and whose hydrographic and topographic characteristics greatly resemble those of the Mississippi, a highly developed and efficiently organized flood control system is in operation. For flood control the whole watershed is subdivided into natural districts organized as private corporations under government coordination and supervision. These districts build and maintain all levees. The government executes all bank protection work and improves and maintains the navigable channel.

"The 'levees only' system is used exclusively on the Tisza. Levee watchmen with headquarters about every 5 km. maintain large stores of fascines and other materials and tools along the levees for emergency use. Enlargement of levee cross-sections to new standards prescribed as a result of the 1919 maximum flood is still in progress in many localities. Manual construction methods are used throughout.

"In the execution of the Tisza improvement project some 112 cut-offs have been constructed, which have shortened the natural river course about 35 per cent. No protective measures were taken before the cut-offs were made to limit the extent of subsequent bank erosion. Although this straightening has produced a quicker discharge and shorter duration of dangerous flood stages, it has also produced serious difficulties in bank erosion due to increased velocities, and in channel maintenance in straight cut-off reaches. These difficulties are being combated by the engineering skill of the present generation. The serpentine trace with the best natural curvatures is strongly favored by the present engineers, even for desirable and necessary cut-offs.

"The Hydrographic Bureau of the Hungarian Government, which issues daily hydrographic maps—similar to weather maps—showing river stages and flood predictions of vital concern to navigation and levee districts, is a highly efficient organization."

Society Delegates at Political and Social Science Meeting

MANY interesting and timely addresses on all phases of our international relationships—economic, social, and political—were given at the 35th annual meeting of the American Academy of Political and Social Science, held in Philadelphia, April 17 and 18, 1931. The Society was represented at this meeting by three delegates, Thomas Buckley, M. Am. Soc. C.E., Philip H. Carlin, Assoc. M. Am. Soc. C.E., and Charles A. Howland, Assoc. M. Am. Soc. C.E., who have given an interesting and comprehensive report of the various proceedings.

COMING EVENTS

ST. PAUL IN OCTOBER!

FALL MEETING OF THE AMERICAN SOCIETY OF CIVIL ENGINEERS

St. Paul, Minn.

October 7, 8, 9, 10, 1931

AMERICAN INSTITUTE OF ELECTRICAL ENGINEERS

Annual Pacific Coast Convention, at Lake Tahoe, Calif., August 25–28

A.S.T.M. Election Results

RESULTS of the election of officers for the year 1931–1932 were recently announced by the American Society for Testing Materials. The new officers are as follows:

President, Frank O. Clements, Technical Director, Research Laboratories, General Motors Corporation, Detroit.

Vice-President, Samuel T. Wagner, M. Am. Soc. C.E., Consulting Engineer, Reading Company, Philadelphia.

Members of Executive Committee, Arthur W. Carpenter, Manager, Testing Laboratories, B. F. Goodrich Company, Akron; Kenneth B. Cook, Technical Manager, Manville Jenckes Company, Pawtucket, R.I.; J. B. Johnson, Chief, Material Branch, Material Division, U.S. Army Air Corps, Wright Field, Dayton; George C. D. Lenth, M. Am. Soc. C.E., Consulting Engineer, Chicago; O. L. Moore, Engineer of Tests, Universal Atlas Cement Company, Chicago.

S.P.E.E. Elects Officers

AT the 39th annual meeting of the Society for the Promotion of Engineering Education, held at Purdue University, June 17–19, officers were elected for the coming year as follows:

President, H. S. Evans, Dean, College of Engineering, University of Colorado, Boulder, Colo.

Vice-Presidents, Harvey H. Jordan, M. Am. Soc. C.E., Professor and Head, General Engineering Drawing, and Assistant Dean, College of Engineering, University of Illinois, Urbana; and D. S. Anderson, Dean, College of Engineering, Tulane University, New Orleans.

Secretary, F. L. Bishop, University of Pittsburgh, Pittsburgh.

Treasurer, W. O. Wiley, John Wiley and Sons, New York, N.Y.

Members of Council, A. M. Dudley, Engineering Supervisor of Development, Westinghouse Electric and Manufacturing Company, East Pittsburgh, Pa.; George A. Stetson, Editor, *A.S.M.E.*, New York, N.Y.; L. E. Conrad, M. Am. Soc. C.E., Professor and Head, Department of Civil Engineering, Kansas State Agricultural College, Manhattan, Kans.; Frank L. Eidmann, Professor of Mechanical Engineering, Columbia University, New York, N.Y.; Ben G. Elliott, Professor of Mechanical Engineering, University of Wisconsin, Madison, Wis.; Arthur E. Norton, Associate Professor of Mechanical Engineering, Harvard University, Cambridge, Mass.; and Elgin R. Wilcox, Associate Professor of General Engineering, University of Washington, Seattle.

Of Interest to Bridge and Highway Engineers

TWO VOLUMES of value to bridge and highway engineers have just been published by the American Association of State Highway Officials. One volume, *Tentative Standard Specifications for Highway Materials and Methods of Sampling and Testing*, gives a comprehensive summary of all specifications in this field that have been adopted by the association. The other volume, *Specifications for Highway Bridges and Incidental Structures*, contains in complete form the standards adopted by the association and deals fully with the subject of concrete, steel, and timber bridges.

Many methods of sampling and testing materials are published for the first time in the volume on highways. Seventy-four such methods are presented and, since many of them are similar to the standards of the American Society for Testing Materials, references to these standards are given in notes under the titles. Deviations from them are indicated by footnotes following descriptions of the methods. The section dealing with testing materials is well illustrated.

Although the volume dealing with bridges was primarily compiled to meet the requirements of state highway bridge engineers, it is valuable as an authentic reference and guide to all engineers engaged in bridge design. Those features dealing with steel were approved jointly with the bridge engineers of the American Railway Association. The two volumes may be obtained for a nominal sum from the American Association of State Highway Officials, Washington, D.C.

A World-Wide Index Service

ACCORDING to J. E. Hannum, Editor of the Engineering Index Service, a total of about 2,000 different periodicals on the subject of engineering are received by the Service. Of these, 153 deal with civil engineering primarily, and 326 are general in character and include civil engineering within their field. An analysis for the year 1930 showed that, of the total number of publications received, 46 per cent were published in the United States, and 21 per cent were published in English outside the United States, making a total of 67 per cent in English. Of the remaining 33 per cent in other languages, 14 per cent were in German and 7 per cent in French, leaving 12 per cent divided among 14 other European languages and Icelandic, Chinese, and Japanese. These publications come from all over the world, even from Egypt and South Africa.

To get a bit nearer home, the Society subscribes to 34 of the 223 sales divisions into which this wealth of periodical literature is divided—all those divisions which deal exclusively with civil engineering. In the 11 issues of CIVIL ENGINEERING which have appeared to date, nearly 1,100 articles have been selected for inclusion in the department of "Current Periodical Literature"—an average of about 100 each month.

At the end of the calendar year, all the items indexed by the Engineering Index Service are carefully arranged and published in book form. These volumes are available in most libraries.

American Engineers Honored by Greece

IT IS interesting to note that engineers and contractors are receiving public recognition for their accomplishments both in this country and abroad. At the time of the completion of Coolidge Dam in Arizona, bronze tablets containing the names not only of the principal engineers and contractors but also of their humbler associates on the work, were erected.

ENTRANCE TO INSPECTION GALLERIES OF MARATHON DAM
Reproduction of Old Athenian Treasure House

Nor are foreign countries lacking in a realization of the dignity and importance of engineering achievements. In Athens, during the month of June, a festival was held before the ancient Temple of Zeus to inaugurate a new water system for the metropolitan area, costing \$12,500,000. At this time, six engineers and contractors of Ulen and Company, who were largely responsible for the design and construction of the project, were signally honored by the government of Greece.

Those receiving the awards were Henry Ulen, who was made a Grand Officer of the Phoenix, the highest honor that the government can bestow; Thomas Shepperd, Merton Keefe, and Roy Gausmann, all Members Am. Soc. C.E., who were made Commanders of the Order of the Savior; and Reginald Keays, M. Am. Soc. C.E., and Earl Vaughn, who were made Gold Cross officers of the last-mentioned order.

Bureau of Standards Soil Corrosion Tests

IN 1911 the Bureau of Standards began a study of the effect of stray currents from railway lines on corrosion of water and gas utility pipes. The rate of corrosion in different soils was so variable that the soils themselves were thought to be responsible. In 1922, many different kinds of pipes, both coated and uncoated, were buried in various types of soils in selected parts of the country. Samples are removed each two years for observation and measurement.

While no final conclusions can be drawn from the results to date, no proof has so far been discovered that indefinite life can be secured by the use of coatings. Details of the scope of the tests originally planned, and a discussion of the soils involved, are contained in *Technologic Papers of the Bureau of Standards, No. 368*, and in *Soil Corrosion Studies, Research Paper No. 95*. These papers are available at the Government Printing Office, from the Superintendent of Documents, Washington, D.C.

NEWS OF ENGINEERS

From Correspondence and Society Files

CLARENCE RAWHOUSER has accepted a position with the U.S. Bureau of Reclamation at Denver, Colo.

O. H. KOCH has been appointed Director of Public Works at Dallas, Tex. He was formerly a member of the engineering firm of Koch and Fowler.

ARTHUR E. GORMAN, until recently Western Sales Manager of the Pardee Engineering Company, became Filtration Engineer of Chicago on July 1.

W. W. HORNER, Chief Engineer, Sewers and Paving, St. Louis, Mo., has been engaged by Dallas, Tex., to make plans for outlet sewers on Mill Creek and Dallas Branch and to draw up a general drainage plan for the city.

HARRY C. MCCLURE has accepted an appointment as member of the Michigan State Public Utilities Commission. He was City Engineer of Flint, Mich.

E. N. VIDAL, previously Senior Engineer Draftsman at the U.S. Bureau of Reclamation, Denver, Colo., has recently become Associate Engineer.

CHARLES A. BISSELL, who was Chief of the Engineering Division, Bureau of Reclamation, U.S. Department of the Interior at Washington, is now Engineer of the Metropolitan Water District in Los Angeles.

EUGENE KELLER, JR., until recently District Manager of the Philip Carey Company at Memphis, Tenn., has been appointed a Regional Manager of the Armco Culvert Manufacturers Association at Middletown, Ohio.

WILLIAM J. GLUCKERT, JR., is with the Standard Oil Company of Venezuela in Trinidad. He was previously Chief Draftsman for the Creole Petroleum Corporation in Maracaibo, Venezuela.

ARTHUR J. BOASE, who has been a Professor of Civil Engineering at the Pennsylvania Military College, is now Regional Structural Engineer for the Portland Cement Association in Philadelphia.

Lyle M. Entrekin has accepted a position as Engineer with the Steelton Works, McClintic-Marshall Corporation, at Steelton, Pa. He was formerly Assistant Engineer of the Bethlehem Steel Company.

C. G. Arriagada is now Consulting Engineer in Vallenar, Chile. Previous to this, he was Resident Engineer for Barriga, Wachholtz and Allesandri Cia, Ltda., at Santiago, Chile.

A. W. Rohlwing, formerly connected with the Portland Cement Association of Ohio, as Field Engineer, is now special representative of the Bessemer Cement Corporation at Buffalo, N.Y.

William M. Robinson, Jr., Civil and Valuation Engineer, has left Augusta, Ga., where he has had engineering offices and has accepted an appointment, by the Secretary of the Interior, to be first Superintendent of Colonial National Monument, Yorktown, Va.

George E. Oliver is at present with Pregenzer and Sons Company at Harrisburg, Ill. He was, previous to this, associated with the James Anderson Company, Inc., as Construction Engineer.

George H. Guerdrum, a former Office Engineer at Randolph Field, San Antonio, Tex., has been appointed Superintendent of Construction at the U.S. Army Base in Boston.

A. W. Galbreath has opened consulting engineering offices in St. Louis, Mo. Previously, he was Valuation Engineer of the Missouri, Kansas and Texas Lines with headquarters in that city.

E. H. Bruntlett has become Construction Engineer and Superintendent of the United Building Stone Company at Minneapolis, Minn.

Lionel C. Tschudy, formerly Appraisal Engineer for Spooner and Merrill, Inc., at Chicago, is now affiliated with the Emery Peck and Rockwood Development Company at Austin, Tex.

Bernhard Alexander Smith, Civil and Hydraulic Engineer in Melbourne, Victoria, has with D. B. Smith opened offices for the practice of consulting engineering in Melbourne.

David S. Gendell, Jr., has been appointed General Manager of Erection of the McClintic-Marshall Corporation at Bethlehem, Pa. He was previously Erection Manager of the New York District of that company.

William H. Baker, Jr., heretofore Structural Engineer of the Bridge Division of Los Angeles County, is now President and General Manager of the Progressive Signal and Lighting Company, Ltd., of Los Angeles.

S. W. Benham, who was in the Research and Development Department of the Johns-Manville Corporation, has been appointed Assistant Engineer on the staff of the American Standards Association.

Franklin Thomas, Director of the Metropolitan Water District of Southern California, has been appointed by Los Angeles County to check flood control plans for the Big Tujunga Canyon.

John A. Silsbee has opened offices in Tulsa, Okla., as Consulting Petroleum Engineer. He was Director of Petroleum Engineering and Geology, and Vice-President and Director of the Producers' Royalty Corporation in the same city.

Dugald C. Jackson, Professor of Electric Power Production and Distribution, and Head of the Department of Electrical Engineering at the Massachusetts Institute of Technology, was awarded the Lamme Medal of the Society for the Promotion of Engineering Education, for the year's outstanding accomplishment in engineering teaching.

Wayne A. Perkins, who has been Hydraulic Engineer at the office of the State Engineer, Sacramento, Calif., has recently been appointed Engineer of Dams.

H. H. Esselstyn, Civil and Structural Engineer, has opened an office in Detroit, where he will carry on a general consulting business in the engineering profession.

John W. Mangan, previously Associate Hydraulic Engineer of the U.S. Geological Survey at Washington, D.C., is now District Engineer of the U.S. Geological Survey at Harrisburg, Pa.

William B. Duffy, Assistant Superintendent of the J. W. Bishop Company, Worcester, Mass., has been appointed Superintendent of Public Works of the Town of North Andover.

Charles F. Puff, Jr., Engineer and Constructor, Suburban Land Development and Municipal Advisor, at Jenkintown, Pa., has formed a company of his own, Charles F. Puff, Jr., and Staff, at Hillcrest, Pa.

G. S. Rinehart, formerly connected with H. P. Staats in Kent, Conn., is with R. W. Hebard and Company in New York City.

Emil C. Heinrich, at one time an engineer for the Elgin, Joliet, and Eastern Railway of Illinois, has accepted a position as Engineer with the Forest Preserve District of Cook County.

J. L. Starkie has been transferred from the position of Division Engineer of the Gulf, Colorado, and Santa Fe Railway Company at Temple, Tex., to Office Engineer of the same company at Galveston.

Robert J. Paulette, formerly City Engineer in Salina, Kans., is now a Consulting Engineer in that city.

Morrough P. O'Brien has been promoted from Assistant Professor to Associate Professor of Mechanical Engineering, at the University of California in Berkeley.

John E. Skafte is Designing Engineer of the Los Angeles County Flood Control District.

J. P. H. Perry, Vice-President, Turner Construction Company, with headquarters in Chicago, has recently removed his office to New York where he will continue in charge of estimates, contracts, and advertising for his company.

Frederic Bass and A. S. Milinowski have been appointed to the Minnesota State Board of Health.

Roy W. Carlson, Testing Engineer, Los Angeles County Flood Control District, has been selected by the U.S. Bureau of Reclamation to conduct at the University of California, as Research Engineer, studies on concrete problems in connection with the construction of Hoover Dam.

Harry D. Chapman is now City Engineer at El Cerrito, Calif.

Francis J. O'Hara has resigned as Assistant Chief Engineer of the Salt River Valley Water Users Association of Phoenix, Ariz., to establish a consulting office in San Francisco.

Schuyler M. Smith, Assistant Bridge Engineer of the Wabash Railway, has been appointed Bridge Engineer of this line.

W. W. Lane, recently State Engineer of Arizona, has been appointed General Manager and District Engineer of the reorganized Beardsley Irrigation Project, Maricopa County Water Conservation District No. 1.

James H. Wiley has been promoted to the position of Chief Engineer, Board of Railroad Commissioners of North Dakota, to fill the vacancy caused by the resignation of Earle H. Morris. Mr. Wiley was formerly Assistant Chief Engineer.

Earle H. Morris, formerly Chief Engineer, Board of Railroad Commissioners of North Dakota, has been appointed Chief Engineer of the Public Service Commission of West Virginia.

Ossian E. Carr left the position of City Manager at Fort Worth, Tex., to accept a similar position in Oakland, Calif.

Samuel F. Newkirk, Jr., is now Superintendent and Engineer of the Board of Water Commissioners of Elizabeth, N.J. He was formerly Superintendent and Engineer for the Elizabethtown Water Company Consolidated.

Robert M. Johnson has been promoted from Junior to Assistant Engineer, U.S. Engineer Office, Savannah, Ga.

A. D. Wilder, who was connected with the Santa Cruz Company in California, has accepted a position with the Kohala Pineapple Company at Mahukona, Hawaii.

Edmond F. Ludden, Counselor at Law, has opened offices at 521 Fifth Avenue, New York City.

William D. Ayers, formerly Civil Engineer and Surveyor of the Halsey and Ayers Company at Asbury Park, N.J., is at present Manager of the Islip office of Wallace H. Halsey, C.E., Inc.

Edwin L. Scruggs has left Tucker and Laxton Inc., of Charlotte, N.C., and is now an Engineer with the Harrison-Wright Company of that city.

Maxwell M. Upson, Vice-President and General Manager of the Raymond Concrete Pile Company of New York, was the recipient of the honorary degree of Doctor of Engineering conferred by the University of North Dakota at the June commencement exercises.

Changes in Membership Grades

Additions, Transfers, Reinstatements, Deaths, and Resignations

From June 7 to July 9, 1931

Additions to Membership

Adams, William Herbert (Jun. '30), 2225 Grant Boulevard, Syracuse, N.Y.

Adkins, Archibald William (Jun. '31), Junior Engr., Bureau of Reclamation, Denver, Colo.

Allen, Harold Joseph (Assoc. M. '31), with U.S. Engr.'s Office (Res., 3822 Clairmount Ave.), Detroit, Mich.

Anderson, Archibald Lamon (M. '31), Senior Civ. Engr., Constr. Div., War Dept., Office of Quartermaster Gen., Washington, D.C. (Res., Falls Church, Va.).

Anderson, Carlton John (Assoc. M. '31), Care, San. Sewer Dept., City of Dallas, City Hall, Dallas, Tex.

Armstrong, Andrew Scott (M. '31), with Bates & Rogers Constr. Co. (Res., 1605 Chase Ave.), Chicago, Ill.

Armstrong, Wallace Edgar (Assoc. M. '31), Office Engr., U.S. Geological Survey, Territorial Office Bldg., Honolulu, Hawaii.

Baker, Charles Vernon (M. '31), State Constr. Engr. and Asst. State Highway Engr., State Highway Comm., 525 Edgewood Drive, Baton Rouge, La.

Belliveau, Paul Richard Mousseau (Jun. '31), with U.P.R.R., Constr. Dept., Los Angeles (Res., 1185 East 9th St., Long Beach), Calif.

Birt, George Clinton (Jun. '30), Asst. Field Engr., A. J. Glaser, 610 South Jefferson St. (Res., 525 South Madison St.), Muncie, Ind.

Bohden, Victor Leo (Jun. '30), 1516 Third Ave., Beaver Falls, Pa.

Brown, David Tucker (M. '30), Senior Highway Engr., U.S. Bureau of Public Roads, Box 1035, Balboa, Canal Zone.

Brown, Wilbur Gayle (M. '31), Engr., M. of W., Florida East Coast Ry. (Res., 113 King St.), St. Augustine, Fla.

Bullard, Dexter (Jun. '31), Kew Hall, Kew Gardens, N.Y.

Calahan, Pecos Hill (Assoc. M. '31), Engr., The Associated Gen. Contrs. of America, Inc., Los Angeles (Res., 366 West Elk Ave., Glendale), Calif.

Campbell, Henry Bayne (Assoc. M. '31), Asst. Civ. Engr., Interstate Commerce Comm., 1269 Ashland Ave., St. Paul, Minn.

Cavan, Charles Thomas (M. '31), Mgr., Compania Telefonica de Barranquilla, Apartado 263, Barranquilla, Colombia.

Charlton, John Felder (Assoc. M. June '31), Civ. Engr., Charlton & Davis, Box 2086, Fort Lauderdale, Fla.

Coffman, Seymour Franklin, Jr. (Jun. '31), Care, Bureau of Public Roads, 807 Mark Sheldon Bldg., San Francisco, Calif.

Cook, Howard Lee (Jun. '31), Asst. Engr., Robert E. Horton, Box 298, Voorheesville, N.Y.

Cox, Clifford Bugbee (Jun. '31), Care, San. Dist. of Chicago, 910 South Michigan Ave., Chicago, Ill.

Cox, John Joseph (Jun. '31), 549 Isham St., New York, N.Y.

Crocker, Harold Simpson (M. '31), City Engr., City Hall, Brockton, Mass.

Crooker, Harold Maynard (Assoc. M. '31), with State Div. of Water Resources, 530 Palm Ave., Fresno, Calif.

Earle, Robert Mayhew (Jun. '31), Transitman, P.R.R., 137 West 12th St., New York, N.Y.

Engstrom, Clifford Godfred (Jun. '31), Instrumentman and Insp., Springfield Water Works Dept., Cobble Mt. Camp, Westfield, Mass.

Fischer, Harry Otto, Jr. (Jun. '30), 229 Cornell Ave., San Antonio, Tex.

Fornerod, Marcel Francis (Jun. '31), 51 Neue Beckenhofstrasse, Zurich, Switzerland.

Fox, Frederick Carl, Jr. (Jun. '31), Asst. Engr., State Dept. of Public Works (Res. 287 Mill St.), Poughkeepsie, N.Y.

Garrecht, Kenneth Esmond (Jun. '31), Box 99, Freeville, N.Y.

Geiger, Charles Jewell (Assoc. M. '31), Constr. Engr., Pittsburgh-Des Moines Steel Co. (Res., 3505 Meadowcroft Ave., South Hills, Mt. Lebanon), Pittsburgh, Pa.

Goldman, Oscar G. (Assoc. M. '31), Asst. Supt., City Distrib. Dept., Spring Valley Water Co., 425 Mason St., Room 707, San Francisco, Calif.

Goodrich, Edwin Alfred (Assoc. M. '31), Instr., Civ. Eng., Lafayette Coll. (Res., 617 Pardee St.), Easton, Pa.

Gould, Maurice Augustus (Assoc. M. '31), Bridge Designer, State Dept. of Highways, Bridge Dept. (Res., 426 East 17th Ave.), Olympia, Wash.

Greenlee, William David (Assoc. M. '31), Structural Engr., Dept. of Bldg. and Safety, City Hall (Res., 512 South Hobart Boulevard), Los Angeles, Calif.

Greey, Edward Alexander (Assoc. M. '31), Engr. and Quantity Surv., Mathews Constr. Co., Inc. (Res., Ridgeview Rd.), Princeton, N.J.

Guillot, Albert Henry (M. '31), Engr., New Orleans Public Service, Inc. (Res., 1423 Adams St.), New Orleans, La.

Hain, Elmer Lamont (M. '31), Technical and Administrative Asst. to Chf. Topographic Engr., U.S. Geological Survey (Res., 742 Rock Creek Church Rd., N.W.), Washington, D.C.

Hall, Oscar Ingalls, Jr. (Jun. '31), with Puget Sound Bridge & Dredging Co., 1013 Board of Trade Bldg., Portland, Ore.

Hammond, Harold Francis (Jun. '31), 36 Perkins Hall, Cambridge, Mass.

Hammond, Newton LeRoy (M. '31), Div. Engr., Met. Dist. Water Supply Comm., Ware Rd., Enfield, Mass.

Hart, John Paul (M. '31), Pres., The Hart Constr. Co., Inc. (Res., 3618 North Mason St.), Tacoma, Wash.

Hausmann, August Ludwig (Assoc. M. '31), Designer and Checker, The Am. Gas & Elec. Co., 30 Church St. (Res., 54 West 89th St.), New York, N.Y.

Heap, George Albert (Assoc. M. '31), Structural Engr., Div. of Bridges and Structures and Div. of San. Sewer Design, Bureau of Eng., Los Angeles (Res., 1952 Fairburn Ave., West Los Angeles), Calif.

Hitchcock, Embury Mortimore (Jun. '31), Care, Seaboard By-Product Coke Co., Kearny, N.J.

Hughes, William Parker (M. '31), City and County Engr., Water and Street Supt., in Chg. of Public Works, City Hall, Lewiston, Idaho.

Jones, Barton Mills (M. '31), Head, Eng. Dept., Antioch Coll. (Res., 150 East Limestone St.), Yellow Springs, Ohio.

Key, Clyde Cicel (Assoc. M. '31), Dist. Supt., North Eastern Constr. Co. (Res., 2037 Guilford Ave.), Baltimore, Md.

King, Silas Earle (Assoc. M. '31), Steel Designer and Res. Engr., Hercules Powder Co., Inc., Wilmington, Del.

Landon, Ransom Durell (Jun. '31), Asst. Prof., School of Eng., Southern Methodist Univ., Box 180, Southern Methodist Univ., Dallas, Tex.

LeCount, Howard Pierre (Assoc. M. '31), Asst. Engr., New England Power Constr. Co., 89 Broad St., Boston (Res., 14 Quincy St., Wollaston), Mass.

Lilley, Gordon Arthur (Jun. '31), Eng. Draftsman, U.S. Forest Service, San Francisco (Res., 2401 Bowditch St., Berkeley), Calif.

Lingle, Robert Thomas (Assoc. M. '31), Asst. Chf. Engr., The Lake Worth Drainage Dist., 406 Guaranty Bldg., West Palm Beach, Fla.

Long, Frederick Watts, Jr. (Jun. '31), Draftsman, Eng. Dept., Truxillo R.R., Puerto Castilla, Honduras.

MacCubbin, Emmett Chase (Jun. '31), Draftsman, J. E. Greiner Co., 1201 St. Paul St., Baltimore, Md.

McLeod, Neil Roderick (Jun. '30), 216 Inwood Ave., Upper Montclair, N.J.

Magill, Richard Vivian (Jun. '30), 338 Forest Ave., N.E., Atlanta, Ga.

Maier, Edward Leonard (Assoc. M. '30), 2206 Minnesota Ave., S.E., Washington, D.C.

Meier, Judson Marsh (Jun. '31), Recorder and Junior Engr., U.S. Geological Survey, Box 1311, Tucson, Ariz.

Miles, William John (Assoc. M. '31), City Engr. and Chemist (Res., 516 North West 5th St.), Mineral Wells, Tex.

Miller, Julius Louis (Jun. '30), 600 Third St., Ambridge, Pa.

Mitchell, Adolphus (Jun. '31), 500 College St., Kinston, N.C.

Mobley, Gordon Simpkins, Jr. (Jun. '30), 2230 Herschell St., Jacksonville, Fla.

Morrison, Max Allison (Jun. '30), 625 East Ward St., Urbana, Ohio.

Oakland, Godfrey Lyon (Jun. '31), Junior Hydr. Engr., U.S. Geological Survey, Room 202, Old State Capitol, St. Paul, Minn.

Owen, Thomas Walker (M. '31), City Engr. (Res., 804 South Oak St.), Port Angeles, Wash.

Panuzio, Frank Louis (Jun. '31), 514 East Buffalo St., Ithaca, N.Y.

Penson, Frederick Howard (Assoc. M. '31), Research Engr., Simon & Simon (Res., 3412 Spring Garden St.), Philadelphia, Pa.

Perkins, Ralph (Jun. '31), Instrumentman, Los Angeles County San. Dist., 1263 Cypress St., Lomita, Calif.

Phoenix, Zeno (Assoc. M. '31), 451 Grand Ave., Long Island City, N.Y.

Ponco, Jacinto Samonte (Jun. '30), Asst. Civ. Engr., Div. of Architecture, Bureau of Public Works, Manila, Philippine Islands.

Purinton, Walter George (Jun. '30), 53 Prince St., Jamaica Plain, Boston, Mass.

Rae, Maxwell Ivan (Jun. '31), with State Dept. of Public Works, (Res., 1470 Fulton St.), San Francisco, Calif.

Renshaw, Claude Arthur (M. '31), City Mgr. City Hall, Miami Beach, Fla.

Richardson, Harold Ward (Assoc. M. '30), Asst. Editor, *Engineering News-Record*, 10th Ave. at 36th St., New York, N.Y.

Roberts, Kenneth Clark (Assoc. M. '31), Designing Engr., Hamilton Bridge Co. (Res., 78 West Ave., South), Hamilton, Ont., Canada.

Sallans, George Andrew (M. '31), with H. G. Balcom, New York (Res., 3533 Eightieth St., Jackson Heights), N.Y.

Sato, Makoto (Jun. '31), Asst. Engr., Dept. of Interior, Govt. Gen. of Korea, Seoul, Korea.

Scheel, Harvey Andrew Edwin (Jun. '30), Architectural Draftsman, with Supt. of Bldgs. and Grounds, Univ. of Chicago (Res., 5234 Kenwood Ave.), Chicago, Ill.

Schofield, John Thomas (Jun. '30), Box 434, Bound Brook, N.J.

Scott, Donald Cozine (Assoc. M. '31), Cons. Engr. (Scott Eng. Co.), 606 Ellis Bldg., Phoenix, Ariz.

Simpson, George Payton (Assoc. M. '31), Engr., Harris County Nav. Dist., Care, Port Comm., 5th Floor, Court House, Houston, Tex.

Smith, Paul Albert (Assoc. M. '31), Chf. of Party, U.S. Coast & Geodetic Survey, Washington, D.C.

SONDAG, GEORGE WASHINGTON (Assoc. M. '31), Service Engr., California Corrugated Culvert Co., West Berkeley (Res., 2751 Twenty-sixth Ave., Oakland), Calif.

STONE, HAROLD ALFRED (Assoc. M. '31), Director of Research, California Taxpayers' Assoc., 715 Subway Terminal Bldg., Los Angeles Calif.

TAMBURRI, THOMAS (Jun. '31), Transitman with Essex County Engr. (Res., 226 South 6th St.), Newark, N.J.

TAYLOR, WILLIAM CHARLES (Jun. '31), 530 Riverview Rd., Swarthmore, Pa.

THIBODEAU, GEORGE FREDERICK (Assoc. M. '31), Pres., Hagan-Thibodeau Constr. Co., Inc., 45 Waterman Ave., Eden Park, R.I.

THOMPSON, PERCY EDWARD (Jun. '31), with Bridge Div., Los Angeles County Road Dept., Los Angeles (Res., 625 North Vista St., Hollywood), Calif.

TURNER, JAMES HENRY (Assoc. M. '31), Asst. Engr., City of San Francisco (Res., 2290 Seventeenth Ave.), San Francisco, Calif.

VAN HOUTEN, ROBERT WALLACE (Jun. '31), Instr., Newark Coll. of Eng., Newark (Res. 20 Brookside Terrace, Milburn), N.J.

WAILES, CHARLES DEVENPORT, JR. (Assoc. M. '31), Chf., Bldg. Dept., City of Long Beach (Res., 214 Santa Fe Ave.), Long Beach, Calif.

WESTCOTT, FRANK TOURTELLOT (Assoc. M. '31), Treas., Munroe & Westcott, Inc. (Res., 95 High St.), North Attleboro, Mass.

WILLIAMS, LEWIS DANIEL, JR. (M. '31), Mgr. and Engr., Port of Willapa Harbor (Res., 504 Twelfth St.), Raymond, Wash.

WOOD, ARTHUR WILLIAM, JR. (Jun. '30), 329 Hubbell Ave., Syracuse, N.Y.

MEMBERSHIP TRANSFERS

ACKERMAN, ADOLPH JOHN (Jun. '26; Assoc. M. '31), with Hydr. Dept., Aluminum Co. of America, 2400 Oliver Bldg., Pittsburgh, Pa.

BUNN, PAUL KING (Assoc. M. '25; M. '31), Care, The Missouri Valley Bridge & Iron Co., Leavenworth, Kans.

CASTLEMAN, FRANCIS LEE, JR. (Jun. '26; Assoc. M. '31), with Am. Bridge Co., 1712 Widener Bldg. (Res., 12 East Rochelle Ave.), Philadelphia, Pa.

CHILDS, JOHN WARREN (Assoc. M. '26; M. '31), Deputy Commr., State Highway Dept, Patriot Bldg., Concord, N.H.

CROUCH, ARTHUR WEIR (Jun. '24; Assoc. M. '30), Civ. Engr., Tennessee Elec. Power Co., Chattanooga (Res., Rainbow Circle, North Chattanooga), Tenn.

CUMMINGS, HAROLD NEFF (Assoc. M. '29; M. June '31), Prof., Civ. Eng., Newark Coll. of Eng., Newark (Res., 30 Lloyd Pl., Belleville), N.J.

DALE, FREDERICK AMERMAN (Assoc. M. '22; M. June '31), Mgr., Emery, Peck & Rockwood Development Co., 605 Norwood Bldg., Austin, Tex.

FUNK, NORMAN WILL (Assoc. M. '17; M. '31), Dist. Sales Mgr., Kansas City Structural Steel Co., 410 Tramway Bldg., Denver, Colo.

HOLLAND, RAY KINGSBURY (Assoc. M. '14; M. '31), Cons. Engr. (Holland, Ackerman & Holland), 106 East Liberty St., Ann Arbor, Mich.

LING, HUNG HSUN (Jun. '18; Assoc. M. '22; M. '31), Director, Bureau of Constr., Lunghai Ry, Chengchow, Honan, China.

MIKURIYA, TADAFUMI (Jun. '26; Assoc. M. '31), 404-B Forty-third and Chester Aves., Philadelphia, Pa.

MORTON, ROBERT MILLER (Assoc. M. '12; M. '31), Vice-Pres., Am. Bitumuls Co. (Res. 3 Twelfth Ave.), San Francisco, Calif.

NEWELL, ROBERT J. (Assoc. M. '10; M. '31), Care, U.S. Bureau of Reclamation, Ronald, Wash.

POLLARD, ALBERT HARRISON (Jun. '23; Assoc. M. '30), Asst. Engr., Materials and Tests Div., State Highway Dept. (Res., 4212 Ave. D), Austin, Tex.

SANTACRUZ, ARMANDO, JR. (Jun. '24; Assoc. M. '31), Cons. Engr. and Technical Adviser, International Water Comm., Box 14, El Paso, Tex.

SAULT, LEON HERBERT (Assoc. M. '20; M. '31), Gen. Contr., 551 Gilfillan Bldg., St. Paul, Minn.

TOTAL MEMBERSHIP AS OF JULY 9, 1931

Members	5,874
Associate Members	6,331
Corporate Members	12,205
Honorary Members	15
Juniors	2,718
Affiliates	134
Fellows	6
Total	15,078

SCHWARZE, CARL THEODORE (Assoc. M. '07; M. '31), Associate Prof., Civ. Eng., New York Univ., University Heights, New York, N.Y.

SHAW, JOSEPH (Jun. '29; Assoc. M. '31), Chf. Eng., W. A. Bechtel Co., 155 Sansome St., San Francisco, Calif.

UITTI, GEORGE ISAAC (Jun. '28; Assoc. M. '31), Bridge Designer, C.R.I. & P.R.R. (Res., 5500 North Neenah Ave.), Chicago, Ill.

WILCOX, GILBERT Lawrence (Jun. '23; Assoc. M., Feb. '31), Engr., United Engrs. & Constructors, Inc., 122 North Broad St., Philadelphia (Res., 38 North Lansdowne Ave., Lansdowne), Pa.

RESIGNATIONS

BEAM, HENRY JORDAN, Assoc. M., resigned July, '31.

DIEMLING, JAMES FLINTHAM, M., resigned July, '31.

DEATHS

BAILEY, ALBERT ROSS. Elected Assoc. M., July 2, 1913; died June 29, 1931.

CLAYTON, ROBERT MORRIS. Elected M., Mar. 4, 1896; died July 4, 1931.

CONGER, ALGER ADAMS. Elected Assoc. M., Oct. 1, 1902; M., Mar. 12, 1918; died May 26, 1931.

HERON, EUGENE CHRISTOPHER. Elected M., Nov. 9, 1920; died May 23, 1931.

HOWE, EDWARD WILLARD. Elected M., Sept. 7, 1887; died June 27, 1931.

MACKEY, JOHN DERBY CORNELIUS. Elected M., Aug. 28, 1922; died June 9, 1931.

MURPHY, DANIEL WILLIAM. Elected M., Feb. 2, 1909; died May 15, 1931.

PAINTER, PENNELL CHURCHMAN. Elected Assoc. M. Mar. 12, 1918; M., Oct. 15, 1923; died June 18, 1931.

REID, HOMER AUSTIN. Elected Assoc. M., Dec. 4, 1901; died June 9, 1931.

SAUNDERS, WILLIAM LAWRENCE. Elected M., Nov. 3, 1886; died June 25, 1931.

SKINNER, ORVILLE CAMPBELL. Elected M., Aug. 31, 1915; died May 18, 1931.

STRATHMANN, EDWARD CHARLES. Elected Associate M., Nov. 8, 1909; died May 25, 1931.

STRONG CARLTON. Elected M., Jan. 4, 1910; died June 25, 1931.

SWAIN, GEORGE FILLMORE. Elected Affiliate, Sept. 5, 1883; M., Mar. 2, 1892; Hon. M., Oct. 7, 1929; died July 1, 1931.

THORNBURG, LEWIS. Elected Assoc. M., Dec. 15, 1924; M., July 8, 1929; date of death unknown.

Men and Positions Available

These items are from information furnished by the Engineering Societies Employment Service with offices in Chicago, New York, and San Francisco. The Service is available to all members of the contributing societies. A complete statement of the procedure, the location of offices, and the fees is to be found on page 97 of the 1931 Year Book of the Society. Unless otherwise noted, replies should be addressed to the key number, Engineering Societies Employment Service, 31 West 39th Street, New York, N.Y.

Men Available

STRUCTURAL ENGINEER; Assoc. M. Am. Soc. C.E.; 34; married; 7 years varied practical experience, detailing, drafting, estimating, designing, and checking oil refinery, commercial, industrial, education, and office buildings; 7 years as civil engineer with public utility organization, on indoor and outdoor substations, powerhouses, transmission lines, and buildings. Engineering work preferred; sales work considered. C-9070.

CONSTRUCTION ENGINEER, SUPERINTENDENT, ASSISTANT; lines and grades; surveyor on materials, or any supervisory position in construction of roads, bridges of both concrete and steel, hotels, apartment houses, schools, foundations, and concrete structures. Satisfactory references. Salary dependent on proved ability and character of position. Will locate anywhere. Available immediately. C-9400.

STRUCTURAL AND HYDRAULIC ENGINEER; Assoc. M. Am. Soc. C.E.; 32; married; graduate, Worcester Polytechnic Institute; 10 years experience on investigation, design, and layout of hydro-electric projects, and design of hydraulic structures and equipment, bridges, buildings, steam power stations, and gas plant structures. Permanent position desired; location immaterial. C-9424.

STRUCTURAL ENGINEER; Assoc. M. Am. Soc. C.E.; 42; married; technical graduate; 15 years experience, including chief draftsman of important railroad and structural engineer of small fabricating plant. C-9405.

CIVIL AND STRUCTURAL ENGINEER; M. Am. Soc. C.E.; 48; married; graduate, University of Wisconsin; 26 years railroad experience, covering general office executive work as well as design, construction, and maintenance of bridges, buildings, wharves, reinforced concrete, car ferry barges, terminal facilities, and facilities for handling inflammable oils. Pacific Coast preferred. C-7882.

CIVIL ENGINEER; Assoc. M. Am. Soc. C.E.; 30; married; graduate; 4 years experience in railroad construction, maintenance of large Eastern trunk line, and valuation work; 2 years varied experience on flood-control project, including field surveys, hydraulic investigations and computations, railroad relocation, designs, estimates, and preparation of contract drawings. Available immediately. Location immaterial. C-4993.

CIVIL ENGINEER; Jun. Am. Soc. C.E.; 24; single; graduate, 1928; 4 years experience on topography, location, general surveying design of concrete and timber structures, outside supervising, hydraulic design, and checking of design and estimates. Capacity to assume responsibility. Connection with engineering or con-

tracting organization desired. Available immediately. C-9423.

GRADUATE ENGINEER AND LAW STUDENT; Jun. Am. Soc. C.E.; 25; married; desires position as sales engineer, college instructor, or with leading engineering or law firm; 4 years varied experience in design and construction of heavy foundations, steel erection, in general construction large steel company, and as leading consultant on public works improvements and investigations. Location and salary open. C-9481.

ASSISTANT CIVIL ENGINEER; preferably in building construction or design and construction; recent graduate, B.S. degree in C.E.; approximately 13 months actual practical experience; position with the right men and a start on the right road desired. C-7484.

COLLEGE GRADUATE; Jun. Am. Soc. C.E.; 24; married; B.S. in civil engineering; experience in design and inspection of reinforced concrete and steel structures and surveying work. C-9479.

STRUCTURAL STEEL DETAILER AND CHECKER; Jun. Am. Soc. C.E.; 29; graduate, Rensselaer Polytechnic Institute; 4 years experience on all classes of steel structures, including mills, office buildings, and bridges; also, 18 months experience in railway maintenance of way. Location, immaterial. C-9493.

GRADUATE CIVIL ENGINEER; Assoc. M. Am. Soc. C.E.; licensed engineer, New York; 30 years experience municipal water supply: operation, construction, maintenance, extensions, meterage, and watershed reforestation; references; available August 1. C-9508.

GRADUATE CIVIL ENGINEER; Assoc. M. Am. Soc. C.E.; 8 years experience in highway and municipal engineering; 2 years successful teaching; connection desired, preferably as instructor in surveying and highway engineering or with chamber of commerce in charge of highway information. Wide acquaintance with highway departments and practical experience in routing auto traffic. C-5040.

GRADUATE CIVIL ENGINEER; Jun. Am. Soc. C.E.; 25; married; 6 months railroad location and construction; 3 years experience with large company in detailing and design of details for steel structures; permanent position with contracting or consulting engineer desired; also interested in sales engineering. West or Middle West preferred. Reasonable salary. C-9409.

GRADUATE CIVIL ENGINEER; Jun. Am. Soc. C.E.; 26; graduate, Massachusetts Institute of Technology; 4 years experience in detailing and designing steel and concrete for building and hydro-plants; hydraulic laboratory experience building, testing model hydraulic structure and river models, and calibrating fluid meters. Available immediately for field or office. Location, preferably in the East. C-9494.

CONSTRUCTION AND STRUCTURAL ENGINEER; M. Am. Soc. C.E.; 45; registered, Pennsylvania; C.E. degree, Cornell; married; 20 years varied experience in design, construction, and maintenance of bridges and structures, in grading, paving, sewers, and public works; in charge of design and construction of large bridge work; bridge maintenance engineer public works; responsible position with construction company, consulting engineer, or public works department desired. C-9523.

CONSTRUCTION SUPERINTENDENT, ENGINEER; Assoc. M. Am. Soc. C.E.; 39; married; 18 years construction experience on factory and office buildings, steel mills, gas plants, track work, hydro- and steam plants, and storm and sanitary sewers. Available at once. Excellent references. Location immaterial. C-9526.

ENGINEER; M. Am. Soc. C.E; married; graduate, Worcester Polytechnic Institute; professional engineering license, New York; 30 years experience with structural steel, reinforced concrete, and industrial plants; in charge of designers, draftsmen, power house, and chemical plant developments. Location preferred, New England or Middle Atlantic States; will consider any location. Available short notice. C-8306.

STRUCTURAL ENGINEER; Jun. Am. Soc. C.E.; 25; single; degrees, C.E. 1928, and D. Eng. in structural engineering 1931, from Rensselaer Polytechnic Institute; 2 1/2 months structural detailing; 3 months calculation of properties of structural shapes. Position structural design, research, construction, or instructorship desired. Available at once. C-9229.

ENGINEER; Assoc. M. Am. Soc. C.E.; 36; married; graduate, electrical and mechanical; 1 year public utility; 5 years teaching experimental and mechanical engineering; 5 years research in development, design, testing, and construction of municipal garbage and rubbish disposal plants and furnaces for low-grade fuels; desires position; location immaterial. C-9515.

ENGINEERING EXECUTIVE; M. Am. Soc. C.E.; 25 years engineering, executive, and construction experience on municipal, highway, and allied lines. Responsible position desired. Middle States preferred. Available on short notice. C-8700.

CIVIL AND INDUSTRIAL ENGINEER; Assoc. M. Am. Soc. C.E.; university education; 25 years government, municipal, public service, and industrial projects; last 12 years partly devoted to industrial management problems, effecting economies and reorganization. Record covers investigations, reports, designs, estimates, contracts, and supervision. Contact with engineers or managers planning to develop broader fields invited. C-5717.

GRADUATE CIVIL ENGINEER; Assoc. M. Am. Soc. C.E.; 8 years structural experience, including building design, railroad, subway construction, with steel, concrete design, drafting, checking, and estimating; familiar field engineering. Desires connection with construction company, consulting engineer, contractor, or architect, where capacity to assume responsibility and interest in productive activity are appreciated—preferably field engineering, construction, or related work. C-2605.

LICENSED ENGINEER; Assoc. M. Am. Soc. C.E.; registered architect; university degrees; 13 years intensive experience on surveys, design, drafting, estimate, specifications, construction; 4 on municipal work; 9 on buildings—commercial, industrial, institutional, concrete, steel, timber design, and detail. Capable of taking charge, field or office, start to completion, for engineer, contractor, or architect; New York or New Jersey. B-7600.

TUNNEL ENGINEER OR SUPERINTENDENT; M. Am. Soc. C.E.; 44; 20 years experience driving long railway, drainage, and power tunnels in rock. Well up on latest mechanical methods, including concrete lining with pneumatic pressure, plant selection, and layout. Location immaterial. C-9209.

GRADUATE CIVIL ENGINEER; Assoc. M. Am. Soc. C.E.; 30; 2 years subdivision location and construction; 1 year highway location and construction; 4 years design in state highway bridge offices. Position as designer of bridges and structures or connection with structural contractor desired. Location preferred, South or Southwest. C-9535.

GRADUATE ENGINEER; Assoc. M. Am. Soc. C.E.; 34; licensed, New York State; married; intimate knowledge of all phases of construction; 13 years broad practical experience in reinforced concrete and steel structures of all types, designing, estimating, drafting, and following up to completion. C-9540.

YOUNG MAN; 3 years technical college education, civil engineering; forced to leave school as a result of conditions; position as draftsman or surveyor desired; experience and schooling in former employment; thorough training all branches of surveying; also, knowledge of pneumatic tube work gained through previous employment. Excellent references. Willing to travel. C-9547.

WATER WORKS EXECUTIVE, ENGINEER; Assoc. M. Am. Soc. C.E.; graduate civil engineer; served with private water company, consulting engineers, and city manager for 4 years; recently returned from 14 months study and investigation of water properties in Latin America; Pennsylvania license. Interested in business management. Author of several technical articles. C-9538.

EXPERIENCED ENGINEER; Assoc. M. Am. Soc. C.E.; 48; university graduate; 25 years experience hydro-electric developments, including surveys, engineering and economic studies and reports, designs, cost estimates, and construction; direct charge of several large hydro-developments, also large drydock. Open for responsible position. New York or vicinity preferred. C-9569.

CIVIL ENGINEER; 33; married; 2 years experience highway surveys, design, construction; 3 years college instructor in surveying; 5 years general contractor on construction of five industrial, commercial buildings ($100,000 to $600,000), cost accounting, and estimating; estimating, appraisal, valuation work, or position as owner's representative desired; resourceful; adaptable. Willing to travel. C-9539.

GRADUATE CIVIL ENGINEER; Jun. Am. Soc. C.E.; 25; 3 years experience in design and construction of small structures used by gas and electric companies, also underground electrical distribution; position in either engineering or construction desired. Location immaterial. C-9543.

GRADUATE CIVIL ENGINEER; Jun. Am. Soc. C.E.; 27; single; will consider accepting position in any locality, domestic or foreign. Has had responsible charge of location, design, and construction of 80 miles of highway, in both flat and mountainous country. Has also had some experience on waterway surveys. C-1977.

CIVIL ENGINEER; Assoc. M. Am. Soc. C.E.; position as instructor or professor of mathematics, physics, or civil engineering subjects desired; medal in mathematics and honor graduate; 18 years experience, covering surveying and mapmaking thoroughly and including hydraulic, highway, and railway-track material design, and hydro-electric, drainage, and highway construction. C-1035.

CIVIL ENGINEER; Assoc. M. Am. Soc. C.E.; 39; college graduate; 15 years experience in layout, design, estimation, construction, supervision, and consultation in America, Asia, and Europe; fluent in French, German, and Russian; position in foreign trade and promotion abroad desired. Available in October. C-6953.

RECENT BOOKS

New books of interest to Civil Engineers, recently donated by the publishers to the Engineering Societies Library, will be found listed here. A comprehensive statement regarding the service which the Library makes available to members is to be found on pages 87 to 89 of the Year Book for 1931. The statements made regarding the books are taken from the books themselves and this Society is not responsible for them.

PRINCIPLES OF CITY PLANNING. By K. B. Lohmann. New York, McGraw-Hill Book Co., 1931. 395 pp., illus., diagrs., charts, maps, 10 × 6 in., cloth. $4.00.

An account of the whole subject of city planning. The elements and principles of the various branches are presented, together with such general matters as the scope and importance of the work, its possibilities, and the means of its accomplishment.

RECLAMATION OF LAND FROM THE SEA. By F. M. Du-Plat-Taylor. New York, Richard R. Smith, Inc., 1931. 153 pp., illus., diagrs., charts, tables, maps, 10 × 6 in., cloth. 21s.

This volume describes methods of reclamation by enclosure and by filling, and illustrates them by numerous examples, principally in England and Holland.

SURVEYING MANUAL, 2 ed. By H. C. Ives. New York, John Wiley & Sons, 1931. 298 pp., illus., diagrs., charts, tables, 7 × 4 in., leather, $2.25.

This manual is designed especially to meet the needs of students of other branches of engineering than civil engineering, who are studying the elements of surveying. It describes the various instruments and their use, and gives problems.

CURRENT PERIODICAL LITERATURE

Abstracts of Articles on Civil Engineering Subjects from Magazines in This Country and in Foreign Lands

Selected items from the current Civil Engineering Group of the Engineering Index Service, 29 West 39th Street, New York, N.Y. Every article indexed is on file in The Engineering Societies Library, one of the leading technical libraries of the world. Some 2,000 technical publications from 40 countries in 20 languages are received by the Library and are read, abstracted, and indexed by trained engineers. With the information given in the items which follow, you may obtain the article from your own files, from your local library, or direct from the publisher. Photoprints will be supplied by this library at the cost of reproduction, 25 cents per page, or technical translations of the complete text may be obtained when necessary at cost.

BRIDGES

CONCRETE ARCH, AUSTRALIA. The Grey Street Bridge, Brisbane, G. O. Boulton. *Inst. Engrs. Australia—Journal*, vol. 3, no. 4, Apr. 1931, pp. 117–125, 16 figs. Design and construction of bridge consisting of three reinforced concrete arch spans, each 238 ft. center to center of piers; types of foundation include open footings, piled foundations, large cylinders and caissons sunk in river, and small cylinders sunk on land; artificial island method of construction; open dredging operations; conversion to pneumatic type and high-pressure airlock work; construction of submerged reinforced concrete beams connecting caissons in pairs; caisson disease.

CONCRETE GIRDER, GREAT BRITAIN. Montrose Bridge. *Engineer*, vol. 151, no. 3934, June 5, 1931, pp. 616–617, 13 figs. partly on p. 628. Bridge constructed entirely of reinforced concrete, even lamp standards, shades, and reflectors being made of that material; roadway has width of 20 ft. and accommodates two lines of traffic; two footways each 8 ft. wide; center span is 216 ft. in length, and shore spans each 108 ft.; in triangulated part, form of top boom follows closely shape of bending-moment diagrams for line load at center of bridge; means provided for taking up expansions and contractions due to changes of temperature.

HIGHWAY, DESIGN. Principles of Design of Steel Highway Bridges. *Pub. Works*, vol. 62, no. 6, June 1931, pp. 48 and 68. Second part of article previously indexed from *Can. Engr.*, Apr. 14, 1931.

HIGHWAY, SPECIFICATIONS. Specification for the Design of Road Bridges—II, M. G. Dempster. *Commonwealth Engr.*, vol. 18, no. 10, May 1, 1931, pp. 362–371. Concrete superstructures; moments in floor slabs; distribution of concentrated loads on slabs; moments in slabs supported on four sides; web reinforcement; T-beams; secondary beams; rigid frame design; wing walls; columns; steel superstructures; rivets; rolled joists and plate girders; trusses.

RAILROAD, UNITED STATES. The B. & O. R. R. Bridges at Harpers Ferry, P. G. Lang, Jr. *Eng. and Contracting*, vol. 70, no. 5, May 1931, pp. 115–117, 3 figs. Features of railroad bridges constructed at Harpers Ferry, W.Va., since 1836, illustrating evolution of practice in design and construction of railroad bridges during past 75 years.

STEEL ARCH, SYDNEY, AUSTRALIA. The Erection of Sydney Harbor Bridge, J. S. Lewis. *Structural Engr.*, vol. 9, no. 5, May 1931, pp. 174–187 and (discussion) 187–190, 30 figs. Construction of steel arch bridge, including single span of 1,650 ft., and having total length of 3,770 ft.; described in several previously indexed articles.

STEEL TRUSS. K-Type Bracing for Long-Span Bridge Trusses. *Eng. News-Rec.*, vol. 106, no. 20, May 14, 1931, pp. 821. Discussion by D. Patterson of paper previously indexed from issue of Apr. 2, 1931.

STEEL TRUSS, CONSTRUCTION. The Rebuilding of the Bassein Bridges on the Bombay, Baroda and Central India Railway, B. B. Haskew. *Inst. Civil Engrs.—Min. of Proc.*, vol. 230, no. 4762, for mtg. Feb. 25, 1930, pp. 204–233, 12 figs. Construction of two plate-girder railroad bridges, consisting of 25 to 69 spans over 62 ft. each; each pier consists of row of six cast-iron screw cylinders spaced 9 ft. between centers; behavior of cylinders when being screwed; gyratory and lateral movement; skin-friction on shaft of cylinder; launching of main spans; quantity of paint required; pile-screwing experiments; work done and time occupied in screwing; costs.

STEEL TRUSS, STRENGTHENING. The Reconstruction of the Attock Bridge Across the River Indus on the Northwestern Railway, India, W. T. Everall. *Inst. Civil Engrs.—Min. of Proc.*, vol. 230, no. 4767, for mtg. Feb. 25, 1931, pp. 234–258 and (discussion) 259–278, 25 figs., 2 supp. plates at end of book. Expanded version of paper previously indexed from *Eng. News-Rec.*, May 7, 1931.

STEEL TRUSS, SUISUN BAY, CALIF. Design and Erection of the Martinez-Benicia Bridge Superstructure, S. A. Roake. *Eng. News-Rec.*, vol. 106, no. 23, June 4, 1931, pp. 918–922, 5 figs. Construction of steel truss railroad bridge costing $12,000,000, across Suisun Bay near San Francisco; spans erected on movable steel-truss falsework; economic use of silicon steel and heat-treated eyebars pre-tested to full-load capacity; consideration of earthquake forces in design.

SUSPENSION, GOLDEN GATE. Golden Gate Bridge Across San Francisco Bay. *West. Construction News*, vol. 6, no. 9, May 10, 1931, pp. 228–232, 36 figs. Main features of suspension bridge having main span 4,200 ft. long, with side spans each 1,125.41 ft. long; three pages of drawings presenting main structural features of superstructure.

SUSPENSION, HUDSON RIVER. The Hudson River Bridge. *Engineer*, vol. 151, no. 3933, May 29, 1931, pp. 590–594, 15 figs. Summary of principal points of fourth progress report on bridge at New York between Fort Washington and Fort Lee.

Spinning 28,370-Ton Cable for Hudson River Bridge, F. W. Skinner. *Eng. and Contracting*, vol. 70, no. 4, Apr. 1931, pp. 85–87, 6 figs. Methods and equipment by means of which 107,000 mi. of very high strength, standard, acid, open hearth, carbon steel wire were rapidly and safely spun into 4-mile long cables, 36 in. in diameter.

SUSPENSION, STRENGTHENING. Some Municipal Works at Newcastle-on-Tyne, W. J. Steele. *Inst. Mun. and County Engrs.—Journal*, vol. 57, no. 24, May 26, 1931, pp. 1244–1254 and (discussion) 1254–1255, 6 figs. Scotswood suspension bridge strengthening works; total length is 910 ft.; distance between centers of river piers 368 ft.; quay extension, east of Ouse Burn; resurfacing old streets.

BUILDINGS

GLASS. New York's Latest Glass Skyscraper May Mark New Tall Building Trend. *Am. Glass Rev.*, vol. 50, no. 35, May 30, 1931, pp. 27–28, 1 fig. Extensive use of glass in McGraw-Hill Building; more than 85,000 sq. ft. used outside and many thousand more inside; design and construction features.

NEW YORK. Color Built into Skyscraper. *Construction Methods*, vol. 13, no. 6, June 1931, pp. 32–37, 18 figs. Report on erection of steel frame of new 33-story McGraw-Hill Building, in New York City; horizontally striped facade produced by wide bands of blue-green terra cotta blocks, covering spandrels at every floor; plant layout showing location of hoists, derricks, and contractor's yard; columns, of which the heaviest weighed 19½ tons, were fabricated and erected in two-story lengths.

STRUCTURAL STEEL. Rivets or Welds in Steel Buildings, L. H. Miller. *Can. Engr.*, vol. 60, no. 19, May 12, 1931, pp. 26 and 68. Discussion leading to conclusion that there is room for both methods in present-day practice but that more consideration is being given to welding; conditions surrounding electric welding; welding large pressure vessels. Before Building Officials Conference, Toronto.

WIND BRACING. Expert Testimony on Wind Design for Tall Buildings—I, D. C. Coyle. *Eng. News-Rec.*, vol. 106, no. 23, June 4, 1931, pp. 932–934, 3 figs. Portal theories; distortion of wind bent under portal theory assumptions; cantilever methods; distortion of wind bent under cantilever theory assumptions; possible future trends; unit loads.

Supporting a Steel Skyscraper on a Concrete Factory. *Eng. News-Rec.*, vol. 106, no. 24, June 11, 1931, pp. 967–969, 6 figs. Difficult wind-design problem in 30-story Daily News Building, in New York, solved by horizontal truss carrying wind shear around bottom six stories of flat-slab concrete construction; wind-bent designs; wind-bracing connections and column sections.

WIND STRESSES. Force of the Wind on Tall Buildings, E. A. Phillips. *Can. Engr.*, vol. 60, no. 22, June 2, 1931, pp. 13–17, 2 figs. Measurement of gust velocities; probable frequency of high wind pressure; relation of velocity to pressure; variation of velocity with height; variation of wind velocity with height.

CITY AND REGIONAL PLANNING

POPULATION. Checking Past Population Forecasts, N. B. Jacobs and A. W. Skilling. *Eng. News-Rec.*, vol. 106, no. 21, May 21, 1931, pp. 854–856, 2 figs. Population forecasts made in past years for 50 American cities, when checked against actual enumerations made in 1930, show tendency to overestimate future population growths; errors in prediction range from 118 per cent for small communities to only 3 per cent for New York City; method of forecasting; large areas used as controls; making use of factors other than past trends; periodic check-ups.

Predicting Future Population in Western Canada, C. J. Mackenzie. *Eng. Journal*, vol. 14, no. 5, May 1931, pp. 286–291, 9 figs. Author's method of estimating future population in western Canada based on separate consideration of urban and rural areas; study of records for comparable districts and cities in United States.

CONCRETE

CHARTS. Short-Cuts in Structural Design—III, J. R. Griffith. *Concrete*, vol. 38, no. 6, June 1931, pp. 35–38, 3 figs. Reinforced-concrete wall footings designed as cantilevers; shear and bending in wall footings; use of charts illustrated by actual problems.

CONSTRUCTION. The Limitations of Present Knowledge of Concrete Construction, A. E. Lindau. *Pit and Quarry*, vol. 22, no. 4, May 20, 1931, pp. 61–64. Extent to which present knowledge limits use of concrete and reinforced concrete in some important particulars; compressive strength important; present strength limits; question of durability; temperature factors. Before Am. Soc. Testing Materials.

CONSTRUCTION, COSTS. Estimating Cost of Concrete Work—I, L. H. Allen. *Concrete*, vol. 38, no. 6, June 1931, pp. 14–16. Concrete quantities and unit prices; basis on which unit prices are established; summary of labor and material costs.

DISINTEGRATION. More Lessons from Concrete Structures in Service, R. B. Young. *Am. Concrete Inst.—Journal*, vol. 2, no. 9, May 1931, pp. 1065–1089 and (discussion) 1090–1091, 19 figs. Reports on study made, for Hydro-electric Power Commission of Ontario, on behavior of many concrete structures, with view to learning not only their existing condition, but their probable condition in years to come; studies cover observations on canal locks, retaining walls, bridge piers, concrete ships, and hydraulic structures. Bibliography.

Study of Defective Concrete, F. R. McMillan. *Am. Concrete Inst.—Journal*, vol. 2, no. 9, May 1931, pp. 1039–1064, 22 figs. Survey of concrete structures representative of almost every kind of aggregate, method of construction, and condition of exposure found in greater part of United States and portions of Canada; ways in which causes of disintegration or unsatisfactory concrete are identified; examination of both sound and defective concrete essential; evidence of dry mixes, and of unsound aggregate; bonding successive layers; structures faced with richer mixture; consistency and placing.

TESTING. The Concrete Flow Trough, D. M. Burmister. *Am. Soc. Testing Materials—Advance Paper*, no. 57, for mtg. June 22–26, 1931, 16 pp., 8 figs. Investigation to show that

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definite information as to workability of concrete can be obtained by means of flow trough; characteristics of concrete are reflected in varying degrees by its behavior in any given test; flow trough test furnishes two figures which are indicative of these characteristics, namely, flow at ten drops and plasticity coefficient; results show how these figures can be used as basis for comparison of concretes and for design of concrete mixtures.

DAMS

CANAL ZONE. Madden Dam, Panama Canal Zone, R. F. Walter and J. L. Savage. *New Reclamation Era*, vol. 22, no. 4, Apr. 1931, pp. 75–78, 2 figs. Design of straight concrete-gravity dam of 220-ft. maximum height and 1,200 ft. long, also of several earth, gravel, and rock-fill saddle dams, to form storage reservoir on Chagres River to be used in operation of Panama Canal locks.

CONCRETE ARCH, MONTANA. Gibson Dam, Sun River Project—II, Montana. *West. Construction News*, vol. 6, no. 10, May 25, 1931, pp. 253–258, 10 figs. Contractor's plant; camp and crew; excavation for dam; river diversion; mass concrete in dam; selection of aggregate pit and concrete mix; operation of aggregate pit; concrete mixing plant; concrete placing equipment; concreting methods; grouting and drainage; grouting; spillway excavation and lining; lining; outlet works and penstocks.

DESIGN. Comments on a Few Dams and Reservoirs, C. E. Grunsky. *Military Engr.*, vol. 23, no. 128, Mar.-Apr. 1931, pp. 135–139, 8 figs. Notes on Dix River Dam, Gordon Valley Dam, Santa Barbara Dam, and St. Francis Dam. (To be concluded.)

EARTH-FILL, AUSTRALIA. High Earthen Dams with Particular Relationship to the Silvan Dam for Melbourne Water Supply, E. G. Ritchie. *Inst. Engrs. Australia—Journal*, vol. 3, no. 4, Apr. 1931, pp. 133–135, 3 figs. Discussion of article indexed from issue of Dec. 1930.

HOOVER DAM PROJECT. The Biggest Mill and Classifier, C. C. Tillotson. *Min. Journal (Phoenix, Ariz.)*, vol. 15, no. 1, May 30, 1931, pp. 3–4. Action of Colorado River is likened to large crushing and grinding mill; largest boulders, which were not ground up, lodged where slope of river diminishes; criticism of project for dam at point where accumulation of boulders is so deep that foundation will be expensive; profile of Colorado River, indicating advantages of dam and reservoir at or above elevation of Marble Canyon, which would make greater amount of water available for Arizona land.

HYDRAULIC-FILL. Composition of Earth Dams—I. *Eng. News-Rec.*, vol. 106, no. 24, June 11, 1931, pp. 960–966, 1 fig. Symposium of four papers: Further Study of Earth Dams and Better Terminology Needed, J. A. Holmes; Materials in Existing Earth Dams, E. W. Lane; Laboratory Tests Can Never Supplant Sound Judgment, O. N. Floyd; Gradation of Materials in Earth Dams an Important Factor, C. H. Paul.

FLOOD CONTROL

MISSISSIPPI RIVER. Flood Control, W. H. Holcombe. *La. Eng. Soc.—Proc.*, vol. 17, no. 1, Feb. 1931, pp. 14–23. Outline of plan of flood control of Mississippi River in its alluvial valley; adopted by Congress in May 1928.

HYDRO-ELECTRIC POWER PLANTS

CHUTE A CARON, CANADA. The Design of the Chute a Caron Diversion Canal, G. O. Vogan. *Eng. Journal*, vol. 14, no. 5, May 1931, p. 296. Discussion of paper previously indexed from issue of Mar. 1931.

MISSOURI. Construction Features of Osage Hydro-electric Development, A. W. Clark. *Stone and Webster Journal*, vol. 48, no. 6, June 1931, pp. 401–418, 8 figs. Previously indexed from *Eng. News-Rec.*, Mar. 26, 1931.

The Osage Hydro-Electric Project, G. R. Strandberg. *Stone and Webster Jl.*, vol. 48, no. 2, Feb. 1931, pp. 99–112, 8 figs. Previously indexed from *Civil Eng.* (N.Y.), Jan. 1931.

INLAND WATERWAYS

CANALS. The Welland Ship Canal—XIX. *Engineering*, vol. 131, no. 3411, May 29, 1931, pp. 691–694, 12 figs. Operating and locking gear of double-leaf rolling-lift bascule bridge; electrical equipment.

CANAL LOCKS, CONSTRUCTION. Reconstruction of the Twin City Lock, J. R. Johnson. *Military Engr.*, vol. 23, no. 128, Mar.-Apr. 1931, pp. 104–106, 4 figs. Description of repair work construction necessitated by failure of lower miter-sill and loss of lower lock gates at Twin Lock and Dam, Mississippi River between St. Paul and Minneapolis, in August 1929; section of reconstructed lock is about 55 ft. wide and 54 ft. deep.

TOWING CABLEWAYS. Developing Canal Transport. *Mech. Handling*, vol. 18, no. 6, June 1931, pp. 193–194, 2 figs. It is suggested that mechanical haulage be substituted for present antiquated horse haulage; by method described average speed of transport would be increased at least three times, while cost of haulage would be reduced to considerably less than half present cost.

UNITED STATES. Transportation on Inland Waterways—III, E. C. Powers. *Mar. Rev.*, vol. 61, no. 6, June 1931, pp. 30–36, and 62, 18 figs. River terminal facilities; types recommended for various waterways; importance of efficient cargo-handling equipment.

IRRIGATION

CONSTRUCTION. Canal Construction Through Lava Plains, E. B. Darlington. *Explosives Engr.*, vol. 9, no. 6, June 1931, pp. 214–215, 3 figs. Drilling and blasting operations on 60-mile canal under construction to supplement water supply of present Gooding project and to make water available to 36,000 acres of new land; work on Milner-Gooding Canal will not be finished until late in 1931.

LAND RECLAMATION AND DRAINAGE

DRAINAGE CANALS, CONSTRUCTION. Disposal of Spoil and Placing of Riprap Feature Work of Drainage Canal. *Construction Methods*, vol. 13, no. 6, June 1931, pp. 42–45, 10 figs. Construction of section H of River Des Peres stormwater sewer, St. Louis; disposal of spoil; coating of gunite applied to 1,709,000 sq. ft. of riprap.

NEW MEXICO. Ten Million Dollar Conservancy Project, J. D. Holmes. *Earth Mover*, vol. 2, no. 18, Feb. 1931, pp. 15–16 and 36, 4 figs. Description of excavation on project of Middle Rio Grande Conservancy District of Albuquerque, New Mexico, embraces flood control, drainage, and irrigation; 24,000,000 cu. yd. will be moved.

ZUYDER ZEE. The Enclosure and Partial Reclamation of the Zuyder Zee, D. A. Dedel. *Eng. and Contracting*, vol. 70, no. 5, May 1931, pp. 107–113, 8 figs. Outline of famous reclamation achievement in many previously indexed papers.

MATERIALS TESTING

CAST IRON PROPERTIES. Gray Iron Possesses Valuable Engineering Properties. *Foundry*, vol. 59, no. 11, June 1, 1931, pp. 54–56, 8 figs. Summary of factors influencing machinability of cast iron with particular regard to crystal structure.

CONCRETE. Tests of Concrete Conveyed from a Central Mixing Plant, W. A. Slater. *Am. Soc. Testing Materials—Advance Paper*, no. 56, for mtg. June 22–26, 1931, 16 pp., 8 figs. Results of tests made to determine effect on properties of concrete of transporting it for hours in truck whose container consists of closed rotating drum without mixing blades.

NON-FERROUS METALS. Fatigue Tests in Shear of Three Non-Ferrous Metals, H. F. Moore and R. E. Lewis. *Am. Soc. Testing Materials—Advance Paper*, no. 42, for mtg. June 22–26, 1931, 7 pp., 4 figs. Results of tests on copper, brass, and duralumin; testing machines and test specimens used; fatigue tests were made in reversed flexure, reversed torsion, and with cycles of torsion varying from zero to maximum.

PIPE, BENDING STRESSES. The Flexibility of Corrugated Pipes Under Longitudinal Forces and Bending, L. H. Donnell. *Am. Soc. Mech. Engrs.—Advance Paper* for mtg., June 15–16, 1931, 4 pp., 8 figs. Calculation of longitudinal flexibility for several types of corrugations, and derivation of reduced modulus of elasticity by which corrugated pipes can be calculated as if they were straight; experimental confirmation of calculation.

RAILS. The Measurement of Large Brinell Impressions in Steel Rails, H. H. Morgan and J. R. Mooney. *Am. Soc. Testing Materials—Advance Paper*, no. 36, for mtg. June 22–26, 1931, 6 pp., 2 figs. In manufacture of both tee and girder rails, indentation test is made on head of test rails with $^{3}/_{4}$-in. ball and 100,000-lb. load; for measurement of these impressions, Hunt Brinell gage has been developed, which indicates same hardness as is obtained from standard-size Brinell impressions made on machined surface.

RUBBER COMPOUNDS. Methods for Determining the Physical Properties of Certain Rubber Compounds at Low Stresses, R. L. Templin and R. G. Sturm. *Am. Soc. Testing Materials—Advance Paper*, no. 90, for mtg. June 22–26, 1931, 13 pp., 8 figs. Apparatus and technic developed for determining physical properties of rubber compounds having moduli of elasticity ranging from 500 to 50,000 lb. per sq. in.

STRUCTURAL STEEL, YIELD POINT. Report of Research Committee on Yield Point of Structural Steel. *Am. Soc. Testing Materials—Advance Paper*, no. 26, for mtg. June 22–26, 1931, 6 pp., 2 figs. Relationship between rate of strain in wedge-gripped specimens and speed of movable head of testing machine in 120 tests; information from these tests forms basis of present report.

WIRE. Fatigue Testing of Wire, S. M. Shelton. *Am. Soc. Testing Materials—Advance Paper*, no. 40, for mtg. June 22–26, 1931, 10 pp., 4 figs. Method for determination of fatigue limit of wire in its structural shape and condition; results are shown for tests of high-carbon, heat-treated, galvanized steel wire; same wire with zinc coating removed; and low-carbon steel wire.

PUBLIC WORKS ENGINEERING

SIAM. Civil Engineering in Siam, H. E. Babbitt. *Eng. News-Rec.*, vol. 106, no. 23, June 4, 1931, pp. 928–931, 4 figs. Engineering and construction; highways; irrigation; municipal work in Bangkok; water works; expenditures on irrigation projects in Siam; memorial bridge.

PORTS AND MARITIME STRUCTURES

DOCKS, FISHING. New Fish Dock for Grimsby. *Engineer*, vol. 151, no. 3934, June 5, 1931, pp. 618–620, 2 figs. Dock will be formed by building of river embankment 6,800 ft. long; northeast wall will be formed by embankment, which will, for greater part of its length, be parallel with river embankment at distance of 340 ft. from it; cores of embankments will be composed of chalk mounds; works for new dock will include formation of two coaling jetties, one 238 and other 400 ft. long, and two outfitting jetties, one 270 and other 400 ft. long; scheme includes formation of considerable length of new railway sidings.

HARBOR IMPROVEMENTS, CALLAO, PERU. Historic Callao Now Has Improved Harbor, A. S. Taylor. *Compressed Air Mag.*, vol. 36, no. 6, June 1931, pp. 3518–3522, 14 figs. Peruvian port has big marine terminal planned and built by American firm; details of harbor improvements.

RAILROADS, STATIONS, AND TERMINALS

PLATFORMS. Station Platforms of Precast Concrete. *Eng. News-Rec.*, vol. 106, no. 24, June 11, 1931, p. 966, 1 fig. Description of new type of floor paving, used for platforms and passageways of Kinzie Street Station, Chicago, elevated railways, consisting of precast concrete slabs bolted to steel framing and covered with asphaltic filter and wearing surface of asphalt planks.

ROADS AND STREETS

ASPHALT EMULSIONS. Cold - Mixed - Asphalt Manufacture Offers Field for Aggregate Producers, M. P. Wall. *Pit and Quarry*, vol. 22, no. 5, June 3, 1931, pp. 55–56, 1 fig. Methods of preparing and amalgamating mineral aggregate and asphalt binders for building cold-mixed asphalt road; liquefier process; Colprovia process.

ASPHALT, FINISHING MACHINES. Machine-Finishing Asphalt Pavements, C. L. Donovan. *Quarry and Roadmaking*, vol. 36, no. 411, May 1931, pp. 224–225. Paper before Engrs.' Club, Philadelphia; indexed in Engineering Index 1930, p. 1289, from various sources.

ASPHALT, UNITED STATES. Construction of Asphalt Roads in United States, B. E. Gray. *Can. Engr.*, vol. 60, no. 18, May 5, 1931, pp. 56 and 59. Construction of low-cost roads by surface treatment; types of asphalt surface treatment; classification of road types; old roads as bases; classification of surface treatment types.

CONCRETE, EXPANSION JOINTS. Joints and Reinforcement in Concrete Pavements. *Commonwealth Engr.*, vol. 18, no. 10, May 1, 1931, pp. 371–372, 2 figs. Standard joint and reinforcement details for cement concrete pavement; standard cardboard dowel cap.

DESIGN. Highway Economics, S. Johannesson. New York, McGraw-Hill Book Co., 1931, 157 pp., illus., tables. $2.50. Introduction to economics of highway construction which aims to present principles and methods by which cost of producing and operating a finished highway may be determined. Among topics treated are cost of vehicle operation upon highways, cost of delays, loss of time by interruptions of traffic, highway capacity, grade crossing elimination, economic studies, and traffic surveys. Eng. Soc. Lib., N.Y.

DESIGN, CURVES. Easement and Banking of Highway Curves, N. B. Putnam. *West. Construction News*, vol. 6, no. 10, May 25, 1931, pp. 263–264, 1 fig. Discussion of paper by J. W. Howard and F. W. Grumm, indexed in Engineering Index 1929, p. 1592, from issue of Dec. 10, 1929; also author's closure.

DESIGN, SUPER-ELEVATION. How Much Super-elevation at Curves, D. Y. Bate. *Pub. Works*, vol. 62, no. 6, June 1931, pp. 54–55 and 66 and 68, 5 figs. Compilation based on principal recent studies; graphs of formulas for different speeds and radii.

GRAVEL, CONSTRUCTION. Traffic - Bound Gravel Roads in an Illinois Township, J. B. Greuter. *Roads and Streets*, vol. 71, no. 5, May 1931, pp. 181–184, 5 figs. Roanoke Township, in Woodford County, builds 37 miles of traffic-bound washed-gravel roads in one season; planning and investigation; methods and costs of construction.

INTERSECTIONS. The Detail Design of Main Road Intersections, J. P. Porter. *Surveyor*, vol. 79, no. 2,050, May 8, 1931, pp. 509–512, 2 figs. Points in design of contoured road intersection; detail design of contours; construction details; foundation and subfoundation problems; carriageway construction problems. (Concluded.)

PAVEMENTS, BRICK. Vitrified Brick Pavement on Metal Base, G. F. Schlesinger. *Can. Engr.*, vol. 60, no. 23, June 9, 1931, pp. 25–26 and 65, 1

fig. Favorable results obtained from short section of experimental road in Illinois; subsoil conditions; construction of surface course; durability; cost of construction; advantages of metal base.

SURFACE TREATMENT. Heating For Non-Skid Street Surfaces, R. S. Dulin. *West. City*, vol. 7, no. 6, June 1931, p. 30, 1 fig. Surface heater loosens flush coat of asphalt which is then raked off and bituminous mixture below is brought to surface; cost data.

Surface Treatment for Roads in Oregon, A., R. H. Babcock. *Commonwealth Engr.*, vol. 18, no. 10, May 1, 1931, pp. 381–384. First treatments with asphaltic oil or tar; use of heavy oils; road mix treatments; bituminous macadam construction; design for new foundations and wearing courses; cost of various types of treatment; non-skid treatment for black pavement.

SEWERAGE AND SEWAGE DISPOSAL

DISPOSAL PLANTS, GREAT BRITAIN. Cheltenham Sewage Purification Works, J. S. Pickering. *Surveyor*, vol. 79, no. 2,052, May 22, 1931, pp. 559–560, 1 fig. Account of operation of Cheltenham sewage purification works over period of 16 years; corporation owns two sewage farms, having irrigable area of 330 acres; sludge disposal; treatment of gas-works liquors; operation of works; annual cost of disposal.

DISPOSAL PLANTS, OPERATION. Operation and Control of Sewage Treatment Plants. *Mun. Sanitation*, vol. 2, no. 6, June 1931, pp. 292–295, 2 figs. Operation of sewage plants; contact beds; secondary or final settling tanks; sludge drying beds; sand filters; disinfection of sewage effluent with chlorine; simple laboratory methods; directions for making test for residual chlorine. (Concluded.)

DISPOSAL PLANTS, OTTAWA, KANS. Flooding of Sewage Works Prevented by High Freeboard, F. M. Veatch. *Eng. News-Rec.*, vol. 106, no. 23, June 4, 1931, p. 927, 2 figs. Data on new Ottawa, Kans., activated-sludge plant designed to be safe from flooding; sewage flow line 10 ft. above ground; exposed walls faced with hollow tile; population served, 12,000; cost of construction $100,000.

JACKING. Jacking a Storm Sewer Under a Busy Street in Nashville, F. Beazley. *Pub. Works*, vol. 62, no. 6, June 1931, pp. 51–52 and 83, 5 figs. Jacking of 52-in. (special diam.), 10-gage Armco corrugated pipe under Eighth Avenue.

PUMPING PLANTS, DESIGN. Pumping Stations at Sewage Plants, C. K. Mathews. *Can. Engr.*, vol. 60, no. 19, May 12, 1931, pp. 27–28. Conditions encountered at disposal plants and methods employed in taking care of them; design of pumping stations; capacity of pumping stations; septic action; automatic operation; sewage pumps. Before Sixth Annual Water and Sewerage Conference.

RUSSIA. The Water and Sewerage Works of Moscow, U.S.S.R., I. S. Walker. *Am. Water Works Assn.—Journal*, vol. 23, no. 5, May 1931, pp. 678–688. Indexed in Engineering Index 1930, p. 1590, from *Engrs. and Eng.*, Nov. 1930.

STRUCTURAL ENGINEERING

ARCHES, DESIGN. Semi-Circular Arches, G. H. Hargreaves. *Surveyor*, vol. 79, no. 2,052, May 22, 1931, pp. 555–558, 7 figs. General principles; tensile stress; determination of loads and effects; live load moments and thrusts at crown and springing; preliminary design; influence lines for bending moments; necessity for checking design.

BEAMS, DESIGN. Reaction, Shear, and Moment Chart, E. McCullough. *Eng. News-Rec.*, vol. 106, no. 20, May 14, 1931, pp. 818–819, 1 fig. Construction of chart and method of using it, to obtain reactions, shears, and moment at any point on span.

CHIMNEYS, BRICK. Radial Brick Chimney Construction. *Can. Engr.*, vol. 60, no. 23, June 9, 1931, pp. 19–22, 7 figs. Chimney built for International Nickel Company, Canada, is 510 ft. high, and 45 ft. inside diameter at top; radial brick used throughout; stress calculations; properties of materials; labor and transportation features.

SURVEYING

MINES. Precise Shaft Surveying—A Factor in Achieving Efficient Ore Hoisting, A. B. Black. *Eng. and Min. Journal*, vol. 131, no. 11, June 8, 1931, pp. 496–499, 9 figs. Previously indexed from Australasian Inst. Min. and Met.—*Proc.*, Sept. 30, 1930.

ROAD DESIGN, AERIAL MAPS. Aerial Maps Aid Parkway Construction, L. D. Bell. *Eng. News-Rec.*, vol. 106, no. 24, June 11, 1931, p. 983. Notes on use of aerial topographic maps in planning Long Island State Parkway; maps prepared to scale of 1 in. = 400 ft. were first used in selecting alignment harmonizing with natural beauty of territory traversed.

THEODOLITES. The Tavistock Theodolite. *Engineering*, vol. 131, no. 3,411, May 29, 1931, pp. 696–698, 8 figs. Instrument made by Cooke, Troughton, and Simms, York, Eng., is intended to take the place, in accurate survey work, of all but largest instruments used in primary triangulation; it gives readings direct to one-second of an arc, although its total weight is but $11^1/_4$ lb.

TUNNELS

SUBWAY CONSTRUCTION, BUENOS AIRES. Buenos Aires Subway 4.6 Miles Long Built in Twenty Months. *Eng. News-Rec.*, vol. 106, no. 23, June 4, 1931, pp. 923–926, 9 figs. Report on construction of first section of Lacroze line; second section is under construction; part of route in tunnel; "Tosca" banks stand vertical in open-cut work; design of station in tunnel and of tunnel section between stations; diagram of progressive operations in tunnel driving and lining; tunnel-arch forms; excavating with clay spades.

WATER SUPPLY, DEARBORN, MICH. A Two-Mile Industrial Water Tunnel. *Sci. Am.*, vol. 144, no. 6, June 1931, pp. 404–405, 6 figs. Tunnel being constructed for main power plant of Ford Motor Company, Dearborn, Mich., will have 24-hr. capacity of 1,000,000,000 gal. and will not only provide more cooling water for condensers, but water at lower temperature than heretofore available; it is a true cylinder with inside diameter of 15 ft. and outside diameter of 21 ft.; lining is made up of two thicknesses; outer is composed of interlocking cement; inner lining is of monolithic concrete; tunnel is 12,000 ft. long and is located 60 ft. below surface of ground.

WATER PIPE LINES

COLLAPSING STRENGTH. How to Determine Collapsing Pressure on Pipes. *West. City*, vol. 7, no. 6, June 1931, pp. 30–31. Construction of alignment chart based on formulas by R. T. Stewart for modern lap-welded Bessemer steel tubes; numerical examples illustrating use of chart.

WATER TREATMENT

ANALYSIS, PHILIPPINE ISLANDS. Artesian-Well Waters in Manila and Neighboring Municipalities, R. H. Aguilar and L. Ocampo. *Philippine Journal Science*, vol. 45, no. 2, June 1931, pp. 151–179, 1 map on supp. plate. Collection of samples and chemical analysis of samples; temperature of air and of water; rates of flow; map showing location of wells.

CHLORINATION, PHOTO-ELECTRIC CONTROL. Photo-Electric Control of Chlorine Feed, J. H. Harrington. *Am. Water Works Assn.—Journal*, vol. 23, no. 5, May 1931, pp. 736–739, 1 fig. Description of apparatus of Montreal filtration plant, controlling chemical feed of chlorine and alum; two color cells and two photo-electric cells are optically opposed on either side of common point source of light so that beams after passing through color cells are intercepted by light-sensitive cells; interval schedule for photo-electric control; relation of residual chlorine to developed color and galvanometer current.

FILTRATION MATERIALS, SAND SHRINKAGE. Observations on Filter Sand Shrinkage, W. M. Wallace, R. Hulbert, and D. Feben. *Am. Water Works Assn.—Journal*, vol. 23, no. 6, June 1931, pp. 870–889 and (discussion) 889–895, 8 figs. Recent experience in Detroit with washing filters at exceptionally high wash rates; use of maximum wash after sand cleaning; cleaning sand permits higher wash rates; mud shelf formation retarded and shrinkage reduced; filter beds composed of finer sands are kept clean; clean filter sands give longer runs; shrinkage theory; electrode and circuit for measuring loss of head; extreme and moderate sand shrinkage; relationship between sand shrinkage and horizontal pressure component, during filter run.

IRON REMOVAL. The Iron Removal Plant at Kokoma, Ind., F. P. Stradling. *Am. Water Works Assn.—Journal*, vol. 23, no. 6, June 1931, pp. 906–909. Description of plant consisting of aerating system, filter plant, clear water basin, wash water tank, necessary pipe lines, and sewer, costing $56,000; water supply from 11 deep wells.

MAMARONECK, N.Y. Ferric Iron Coagulation, A. Potter and W. I. Klein. *Am. Water Works Assn.—Journal*, vol. 23, no. 5, May 1931, pp. 719–727. Indexed in Engineering Index 1930, p. 1881, from *Water Works Eng.*, June 18, 1930.

SOFTENING, IOWA. Water Softening Plant Employs Pumped Recirculation for Chemical Mixing, H. N. Jenks. *Eng. News-Rec.*, vol. 106, no. 26, June 25, 1931, pp. 1061–1063, 4 figs. Description of Fort Dodge, Iowa, iron-removal and water-softening plant; aerator combines actions of cascade and flowing stream; softened water recarbonated prior to final sedimentation; filter gages are electrically operated; flocculation takes place in mixing tanks where spiral flow is induced; design characteristics of plant.

SOFTENING, UNITED STATES. Water Softening Practice, C. P. Hoover. *Am. Water Works Assn.—Journal*, vol. 23, no. 6, June 1931, pp. 826–833. Indexed in Engineering Index 1930, p. 1870, from *Eng. News-Rec.*, May 22, 1930.

TASTE AND ODOR REMOVAL. Activated Carbon Removes Tastes and Odors from Water, C. E. Trowbridge. *Pub. Works*, vol. 62, no. 6, June 1931, pp. 19–20 and 60, 2 figs. Experience of South Pittsburgh Water Company and of City of New Castle Water Co., with use of Nuchar carbon.

WATER WORKS ENGINEERING

DEPRECIATION. Common Sense the Prime Essential in Determining the Depreciation of Water Works, G. W. Biggs. *Water Works Eng.*, vol. 84, no. 10, May 20, 1931, pp. 655–656, 730 and 733, 1 fig. Actual versus theoretical depreciation; obsolescence; accrued method found reasonably accurate; improvement in methods of determining valuation of water works properties.

DESIGN. Essential Steps to Be Taken in Protecting Cities Against Drought, F. R. Berry. *Water Works Eng.*, vol. 84, no. 12, June 17, 1931, pp. 881–882 and 905. Some lessons that recent shortage of water impressed upon water works profession; need for better rainfall records; four typical examples of effects of drought; need for re-appraising customary design assumptions; heavy expenditure to correct temporary condition not justified.

Lessons from the 1930 Drought, J. F. Laboon. *Eng. News-Rec.*, vol. 106, no. 21, 1931, pp. 836–838, 3 figs. Experiences of number of water systems; basic design assumptions must be revised; zero yields, high maximum-average consumption ratios, and quality depreciation are main factors affecting water service in times of shortage.

EMERGENCY CONSTRUCTION. Quick Work in Meeting Drought Emergency at San Francisco, M. M. O'Shaughnessy. *Water Works Eng.*, vol. 84, no. 10, May 20, 1931, pp. 663–664 and 773–738, 9 figs. Recent well drilling by Spring Valley Water Co., in 1924; construction of connection with East Bay Municipal Utility District, consisting of 35,000 ft. of 44 in. by $^5/_{16}$-in. and 32,000 ft. of 36 in. by $^1/_4$-in. welded steel pipe with asphaltic coating and protective wrapping.

EMERGENCY SUPPLIES. Safeguarding Emergency Water Supplies, L. H. Enslow. *Eng. News-Rec.*, vol. 106, no. 21, May 21, 1931, pp. 838–841, 5 figs. Necessity of preparedness in providing adequate treatment for inferior supplies when their use becomes unavoidable; availability of emergency equipment; emergency chlorinators; danger of overdosing; emergency filter plant at Asheville, N.C.; manganese and iron in water supplies; equipment for feeding chlorinated lime; combating taste troubles.

FLORIDA. A New Source Supply for Orlando, Fla., C. F. Underhill. *Am. Water Works Assn.—Journal*, vol. 23, no. 6, June 1931, pp. 851–856. Description of supplementary supply from Lake Underhill; lake is circular in form; shore line area at high water is 175 acres; average depth 20 ft.; cost of acquiring and developing new supply $155,494.

GERMANY. Der Ausbau des Wasserwerks Tegel (Development of Tegel Water Works), Proth. *Gas und Wasserfach*, vol. 74, no. 18, May 2, 1931, pp. 398–406, 10 figs. Recent history of Tegel Lake unit of Berlin water works; description of lake shore wells and electrically operated pumping plant, having capacity of 3,000 cu. m. per hr. against head of 70 m.

MAINTENANCE AND REPAIR. The Round Table. *Water Works Eng.*, vol. 84, no. 11, June 3, 1931, pp. 821–822 and 841. Practical discussion of handling of emergency repairs, such as broken main or hydrant; truck equipment; simplifying detail work.

MANAGEMENT. Development of Wells and 100 Per Cent Meterage to Improve Operating Facilities of a Small Water Company, V. B. Siems. *Water Works Engr.*, vol. 84, no. 10, May 20, 1931, pp. 661–662, 734 and 737, 1 fig. Experience of Laurel Springs, N.J., Water Works Co.; tests show how output of wells can be increased; meterage will reduce consumption; saving in operating expenses; test of wells; study as to proper size pump to use; operating expenses of proposed plant.

PITTSBURGH, PA. The Pittsburgh Water Works—Its History, E. E. Lanpher and V. M. Finch. *Water Works Eng.*, vol. 84, no. 10, May 20, 1931, pp. 651–652 and 5 pp. between pp. 746–754, 14 figs.; see also *Water Works and Sewerage*, vol. 78, no. 5, May 1931, pp. 109–113, 9 figs. History of water works since 1802 and description of modern plant, including filters, pumping stations, and distribution systems.

RECONSTRUCTION. Old Concrete Pump Pit Transformed into Modern Water Plant, H. K. Bell. *Water Works Eng.*, vol. 84, no. 12, June 17, 1931, pp. 879–880 and 909, 4 figs. Description of improvements made to water system in Louisa, Ky., at minimum cost; introduction of meters reduces pumping time.

UNDERGROUND SUPPLY, PHILIPPINE ISLANDS. The Water Supply of Manila from Underground Sources, L. A. Faustino. *Philippine Journal Science*, vol. 45, no. 2, June 1931, pp. 119–149, 6 figs. partly on supp. plate. Survey of geological formations; source and movement of ground water; occurrence of ground water; development and utilization; logs of wells.

UNITED STATES. Drought Problems Studied by A.W.W.A. *Eng. News-Rec.*, vol. 106, no. 23, June 4, 1931, pp. 935–938. Report on meetings of 51st annual convention of American Water Works Assn.; abstract of papers and discussions on drought problems; taste and odor removal; special Pittsburgh problems; distribution